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Scientific Investigations

TWENTY-SIXTH
ANNUAL REPORT

OF THE

FISHERY BOARD FOR SCOTLAND,

Being for the Year 1907.

IN THREE PARTS.

PART I.—GENERAL REPORT.
PART II.—REPORT ON SALMON FISHERIES.
PART III.—SCIENTIFIC INVESTIGATIONS.

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Presented to both Houses of Parliament by Command of His Majesty.

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CONTENTS.

SCIENTIFIC REPORTS.

TWENTY-SIXTH ANNUAL REPORT.

TO THE RIGHT HONOURABLE

JOHN SINCLAIR, M. P.,

His Majesty's Secretary for Scotland.

OFFICE OF THE FISHERY BOARD
FOR SCOTLAND,
EDINBURGH, 11*th December*, 1908.

SIR,

In continuation of our Twenty-sixth Annual Report, we have the honour to submit—

PART III.—SCIENTIFIC INVESTIGATIONS.

GENERAL STATEMENT.

This part of the Twenty-sixth Annual Report deals with the scientific investigations which have been conducted by the Board in 1907 in connection with the sea fisheries of Scotland, so far as they have been completed, by means of the Parliamentary Vote granted for the purpose.

The scientific work has, as usual, been carried out under the supervision of Dr. T. Wemyss Fulton, the Scientific Superintendent under the Board, the researches having been for the most part undertaken at the Board's Marine Laboratory, Bay of Nigg, Aberdeen, and partly in the Firth of Clyde. The hatchery for sea fishes is also situated at Aberdeen, and a statement of the work done at it during the year will be found below.

As was explained in previous Reports, the investigations into the condition of the fishing-grounds in the Moray Firth and Aberdeen Bay by means of commercial trawlers specially employed for that purpose was discontinued at the end of 1905, but the statistics of the catches of line fishermen within the Moray Firth continue to be collected.

In the Firth of Clyde, and in Loch Fyne in particular, the investigation into the herring fishery which has been in progress during the last few years was continued, and it is intended to

pursue the observations on the temperature of the water and the abundance of plankton or floating herring-food until the fishery improves, so as to bridge over the period of depression, which unfortunately still continues, and to ascertain whether the scarcity of herrings was related to one or other of these conditions. A fuller statement on this investigation is given below.

The Hatching of Plaice.

In the season of 1907 the hatching of the eggs of the plaice at the Bay of Nigg Hatchery was continued as in previous years, but owing to the fact that the supply of the spawning adults was the lowest since the work was commenced, the number of the fertilised eggs collected from the spawning pond, and consequently the number of fry obtained and planted in the sea, was the lowest for any year. Although the capacity of the spawning pond allows of much more than a thousand plaice being retained in it with ease, only 87 fishes, including males and females, were available for the supply of fertilised spawn. The cause of the decrease was the difficulty of obtaining supplies of adult fishes. Hitherto the stock was obtained by the use of a trawler which was permitted to fish in the bays of the Moray Firth and in Aberdeen Bay for the purpose of securing a supply, all the plaice which were suitable for the hatchery being brought ashore in tubs, the remainder of the fishes taken becoming the property of the owner of the trawler as recompense for the use of the vessel. This arrangement was interrupted at the end of 1905, as explained in last Report, the plaice since obtained for the hatchery being brought ashore by the "Goldseeker," the vessel employed in the international fishery investigations. Plaice of the kind required are only to be caught in any quantity on the inshore grounds where trawling, except for scientific purposes, is prohibited. Under present circumstances it is not possible to get sufficient supplies from the ordinary commercial trawlers working on the offshore grounds. The quantity of plaice obtained by them on any single voyage is, as a rule, small, and it would require many expeditions of the kind to procure an adequate stock, and, as the fish would require to be purchased at their market value, the cost would be very considerable.

The total number of the eggs of the plaice collected from the pond in the course of the season of 1907 was estimated at about 1,627,000, as compared with 7,486,000 in 1906 and over 40,000,000 in 1905. The estimated number of place larvæ, or fry, obtained from them and "planted" in the sea on the neighbouring parts of the coast of Aberdeenshire was 1,282,000, the loss in incubation amounting to about 21 per cent. Owing to the small numbers of fry that were at any one time available, it was not thought to be desirable to incur the expense of transporting them to the northern parts of the coast as in former years, as was requested by the fishermen of the localities. The number of eggs and fry dealt with since the work was begun at the Bay of Nigg is shown in the following Table :—

Year.	Eggs Collected.	Fry Liberated.
1900 . . .	43,290,000	31,305,000
1901 . . .	63,377,000	51,800,000
1902 . . .	72,410,000	55,700,000
1903 . . .	65,940,000	53,600,000
1904 . . .	39,600,000	34,780,000
1905 . . .	40,110,000	24,500,000
1906 . . .	7,486,000	4,406,000
1907 . . .	1,627,000	1,282,000

Owing to the fact that the hatching work is carried on in conjunction with the work of the Marine Laboratory, its cost is relatively small, the extra expenditure on coals, food for the fishes, &c., being estimated at about £80.

The Loch Fyne Experiments with Plaice Fry.

To the present Report Dr. Fulton contributes a paper descriptive of the problems and principles of the artificial propagation of sea fishes, dealing especially with the proofs of the results of the work which have been brought forward, and in particular with the experiments on the effects of the liberation of large numbers of plaice fry in Loch Fyne, which were begun thirteen years ago and have been carried on since then in each year. Hatcheries for the propagation of sea fishes now exist in America, Norway, New Zealand, New South Wales, Scotland, and England, where there are two, one at Piel and the other at Port Erin, in the Isle of Man. In the United States, where the amount of money voted by Congress for piscicultural work in the year 1906-1907 amounted to 454,180 dollars, or about £94,600, there are three permanent hatcheries and several temporary hatcheries devoted to the artificial propagation of marine fishes, the output of fry from them in the year aggregating over 503,000,000 and 168,000,000 lobsters. In Canada the amount appropriated for pisciculture was nearly £33,000, five hatcheries being engaged in lobster culture, the output of young lobsters amounting to 501,000,000. With regard to the benefits accruing from these operations, the Fish Commissioner of the United States reports that encouraging results of the efforts of the Government to maintain the fish supply by artificial means appear in reports from fishermen and fish culturists in all parts of the country; and that, although it is difficult to establish definitely the extent to which the hatcheries have affected the condition of the commercial fisheries of the coastal waters and the Great Lakes, the renewed productiveness of old and abandoned fishing grounds and the abundance of fish on entirely new areas are strongly indicative.

Proof of the amount of benefit derived from the artificial propagation of sea fishes is very difficult to obtain, since in almost all cases the fry which were added to any area of water are simply an addition to the fry which naturally exist there; and there is no system of statistics in use which would enable the effect of the liberation of fry on the quantity of fishes subsequently caught to

be measured or to be separated from the fluctuations due to other causes, whether natural or artificial. An exception was the case of the introduction of the shad to the waters of the Pacific by the United States Commission. Fry of this fish, which did not exist there, were brought from the Atlanric coast between 1873 and 1880, the total number being comparatively small, viz., 619,000. From these colonies the shad increased to such an extent that in 1895 it was reported to be one of the most abundant fishes of California, and had extended along 2700 miles of coast line. With the view of ascertaining the effect of the liberation of the fry of plaice, considerable numbers of them were transferred to Loch Fyne from the hatchery of the Fishery Board in the years 1896-1901, and a few months later the abundance of the young plaice to be found in certain localities in the loch was tested by fishing with a push-net on the beach. In the six years 1903-1908 no fry were placed in the loch, and the push-nettings were continued at the same places and at corresponding times in order to determine the abundance of the young fish in the same way. The total number of the year's plaice which were obtained was 13,068, the collective results in the two periods being as follows:—

	No. of Fry Liberated.	No. of Hours Fishing.	No. of Plaice.	Average No. per Hour.
1896-1901,	142,880,000	74	6,491	87·7
1902-1908,	None.	$165\frac{1}{2}$	6,577	39·7

Thus, in the first period, when plaice fry were being put into the loch, the average number of young plaice taken was 87·7 per hour, whereas in the second period, when no plaice fry were added, the average number taken per hour was 39·7, or less than half. The average at each of the five stations where collections were made was less in the second period than in the first, the decrease per hour ranging from 19·2 to 104·7. The collections were made in the months of June, July, August, and September, and the mean number of young plaice taken per hour was less in each month in the second period than in the first, and, with one or two exceptions, this was true of each of the stations considered separately. As shown in the accompanying Table, the fluctuations from year to year were very considerable, the mean annual average ranging in the first period from 24 to 174, and in the second period from 8 to 112. When the average was high at one station or in one month it was also, with few exceptions, high at the other stations and in the other months, and so when it was low, and thus the numbers represent approximately an actual abundance or scarcity of the young plaice in Loch Fyne in the particular years.

Year.	No. of Fry Liberated.	Duration of Fishing.		No. of Plaice taken.	Average No. per Hour.
		Hrs.	Mins.		
1896	4,100,000	10	0	1,114	111·4
1897	21,170,000	2	30	60	24·0
1898	19,200,000	12	30	1,195	95·6
1899	16,470,000	17	0	488	28·7
1900	30,590,000	16	0	850	53·1
1901	51,350,000	16	0	2,784	174·0
1903	None.	33	0	1,231	37·3
1904	None.	31	45	253	8·0
1905	None.	29	45	3,333	112·0
1906	None.	30	25	505	16·6
1907	None.	8	50	294	33·3
1908	None.	31	45	961	30·3

The period of thirteen years over which those experiments have extended is a considerable one, and Dr. Fulton thinks it is reasonable to believe that the greatly increased average abundance of the young plaice in the first six years was mainly due to the liberation of the 142,880,000 fry in those years; and that, on the other hand, the decrease in the abundance in the last six years was mainly owing to the fact that no plaice fry were added to the loch in these years. These conclusions are supported by a mathematical investigation of the fluctuations in the averages by Miss Lee, of the Marine Biological Laboratory, Lowestoft, to whom the figures were submitted, but a further series of observations would be very valuable, especially to determine more precisely the natural fluctuations.

Investigations on the Herring Fishery of Loch Fyne.

Since the latter part of 1904, as mentioned in previous Reports of the Board, investigations have been pursued with regard to the herring fishery in Loch Fyne, as far as the means at disposal have admitted. The enquiry was commenced owing to the failure of this important fishery for a series of years, as the following figures, showing the quantity of herrings (in crans), make evident:—

Year.	Herrings Caught.	Year.	Herrings Caught.
1895, - -	17,853	1901, - -	29,117
1896, - -	18,406	1902, - -	26,339
1897, - -	56,820	1903, - -	21,198
1898, - -	40,801	1904, - -	7,827
1899, - -	32,113	1905, - -	4,672
1900, - -	24,743	1906, - -	5,258
		1907, - -	3,914

There has thus been an almost continuous decline since the year 1897, which, however, represented the largest quantity which has been recorded as taken from the loch, and the decrease during the last four years has been very marked, and unfortunately still continues. The object of the enquiry was to ascertain, as far as possible, the nature and extent of the annual fluctuations in the abundance of the herrings, their causes, and the movements of the shoals into and out of Loch Fyne. In last year's Report a paper was published dealing with all the available statistics for the period from 1854 to 1906, and showing the annual fluctuations which had taken place in that period. It was brought out that about thirty-three years ago a very similar time of depression and poor fishing occurred, the yield gradually falling from 39,795 crans in 1868 to 3648 crans in 1873 and 4806 crans in 1874, after which it rose, at first with some irregularity, to 55,754 crans in 1882, the second largest quantity recorded from the loch, and fell again to 1886 and 1887, when it was considerably below the average. There is no good reason to suppose that the present poor yield will not be followed by corresponding years of abundance as in the past, or that it is in the main, at all events, anything but the trough of one of the waves of scarcity and plenty which have characterised the fishing during the last half-century. The investigations to which reference has been made comprise the determination of the temperature of the water, the abundance of the planktonic food of the herring, and the examination of samples of fish from various parts of the Clyde in relation especially to the condition of the reproductive organs. Variations in the temperature of the sea and in the quantity of food upon which the herrings live are believed by many to be causes producing fluctuations in the herring fishery, and when observations are completed, that is, when the herrings return in something like their normal numbers, they will probably show to what extent this explanation is correct. In addition to the regular serial observations of the temperatures in Loch Fyne made by means of a small yacht, other observations have been made in the Clyde by the fishery cruiser "Vigilant."

The Decomposition of Fish.

In the present Report will be found a paper by Dr. A. G. Anderson giving the results of an investigation undertaken by him on the processes involved in the decomposition of fish, including a bacteriological study of the subject, the observations and experiments having been made partly at the Board's Marine Laboratory and partly in the laboratories of Marischal College, Aberdeen. Fresh fish, from its essential nature, readily undergoes decomposition, the process being associated with and chiefly caused by micro-organisms which are universally present, the three chief factors which facilitate or inhibit their action being the supply of nourishment, the temperature, and the degree of moisture. Compared with the red muscles of mammals the pale muscles, or edible portion, of fishes have usually less fat and much more water, are slightly less vascular and looser in texture, and are thus more susceptible to the attack of putrefactive micro-organisms.

Excluding the gut, micro-organisms do not exist to any appreciable extent in the tissues or body fluids of fish under normal conditions, but after death the tissues offer comparatively little resistance to the invasion of putrefactive organisms, which are soon found multiplying in great numbers in the gut and all the body fluids, gradually penetrating amongst the surrounding tissues. Among the products of their activity are some substances of an alkaloidal nature which are very poisonous and have recently been isolated from decomposing fish; one class, mytilotoxin, acts chiefly on the nervous system, paralysing motor nerves like curara, while another class affect the digestive organs, causing acute gastritis and enteritis. It is thus a matter of importance to be able to detect the earlier stages of decomposition in fish, which are sometimes disguised. The criteria which Dr. Anderson considers in detail are the general appearance of the fish, the firmness or softness of the flesh, the appearance of the surface and scales of the eyes and gills, the smell, the discolouration on the ventral aspect of the backbone, rigor mortis, the manner in which the flesh strips away from the backbone, and the appearance of the abdominal walls as affected by the gut.

Since it is possible to inhibit the action of most bacteria of putrefaction by maintaining a low temperature of from 0° C. to —3° C., while at the same time maintaining the fish in a condition of rigor, fish may be preserved in a comparatively fresh condition for a considerable time with very little deterioration in their tissues, but at temperatures below —3° C. they suffer considerably, the muscles on thawing being very soft and limp, and such fish are difficult to cure, have lost much of their natural flavour, and readily undergo decomposition. As a result of experiments to determine the question as to the best time to ice fish, as on board trawlers, whether before, after, or during rigor, Dr. Anderson found that those which had been iced when rigor was completed were distinctly superior to those iced before rigor had set in or after it had disappeared, the next best being those dealt with before rigor supervened. The experiments were made on haddocks and whitings, ungutted and gutted. It was found that rigor generally set in earlier and disappeared earlier in trawled fish than in fish caught by line, and since this allows of the earlier onset of decomposition, it is concluded that the former are not equal to the latter either in general condition, curing properties or keeping properties. The author describes with technical detail the bacteriological part of the investigation.

The Specific Characters of the Gadidæ.

In continnation of two previous papers on this subject, Dr. Williamson contributes to the present Report a paper on the specific characters of the haddock, whiting, and some other less known members of the genus Gadus, together with a key to the species of that genus which are found in northern waters. In a group of fishes, as that of this genus, it is not possible to separate the different members by a simple scheme, because the character which may be of value for separating two species may be quite neutral in the other members. It is therefore necessary to take

the characters of the fish *seriatim*, making each one a basis of classification. It has usually been thought necessary to subdivide the genus by the test of a single character—for example, by the question of whether the upper or the lower jaw forms the most anterior point of the fish when the mouth is closed. Then in each sub-group the individual members were separated by other characters. Theoretically this is a convenient arrangement, but in practice it is of little value in some cases, for the first selected character may not be readily recognisable in some specimens, and in that case the diagnosis may not be obtained. The specific characters of the various forms dealt with are described in detail, and are illustrated by numerous tables and six plates.

The Parasites of Fishes.

A paper, illustrated by five plates, descriptive of certain parasites infesting fish is contributed to this Report by Dr. Thomas Scott, in continuation of other papers on the same subject which have appeared in former Reports. They include both ectoparasites and endoparasites, three species of the former being new to science, while some rare and curious forms are comprised among those belonging to the latter group. Dr. Scott states that in the many cases of parasitism in fish that have come under his notice, he has usually been unable to observe any very serious results produced by the presence of the parasites; and in cases where the fish were much emaciated it was a moot point whether the emaciation was caused by the parasites or due to other causes.

Scientific and Technical Instruction to Fishermen.

For some years past, as mentioned in previous Reports, representative fishermen selected by the Technical Committees of various counties have visited the Marine Laboratory and Hatchery to receive demonstrations and instruction relating to the life-history and habits of the food fishes, such as might be of interest and use to them, and to see the processes of fish-hatching. Owing to a misunderstanding as to the scope of the invitation formerly issued by the Board, no delegates attended in the spring of 1907, but in the spring of this year representatives came from the Counties of Elgin and Caithness.

We have the honour to be,

Sir,

Your most obedient Servants,

ANGUS SUTHERLAND, *Chairman.*
D. CRAWFORD, *Deputy-Chairman.*
D'ARCY W. THOMPSON.
W. R. DUGUID.
L. MILLOY.
D. MEARNS.
H. WATSON.

WM. C. ROBERTSON, *Secretary.*

SCIENTIFIC REPORTS.

I.—ON THE DECOMPOSITION OF FISH. By Dr. A. G. Anderson, M.A., M.D., B.Sc., D.P.H., Assistant to the Medical Officer of Health, Aberdeen. (Pl. I.)

Table of Contents.

1. Introduction: General Review and Discussion.

During the past two years, in my capacity as Assistant to the Medical Officer of Health in Aberdeen, I have had frequently to deal with hygienic problems relating to trawling, fishcuring, and the examination of fish. In many cases I have been unfavourably impressed with the lack of knowledge of the elementary scientific principles underlying the various processes in the different departments of the fishing industry, and with the absence of a spirit of scientific enquiry which is so essential in any progressive business. It was with the aim of stimulating this spirit of enquiry that I commenced some practical studies—the results of some of which are included in this paper—and in the hope that fishermen, fishcurers, and meat inspectors might gain a more intelligent acquaintance with their business, and that thereby the fish-consuming public might also be benefited. I was, moreover, asked by the Fishery Board for Scotland to undertake an investigation on the processes involved in

the putrefaction of fish, including a bacteriological study of the subject, and the observations and experiments referred to below were in part made at the Fishery Board's Marine Laboratory at the Bay of Nigg and partly in the laboratories of Marischal College.

The subject of the putrefaction of fish, it need scarcely be said, concerns not only one of the chief sources of our food supply, but also the interests of a great industry. Fish as a foodstuff has in recent years been gradually gaining in favour, and by the great development of trawling increased supplies have been made available both for use in the fresh condition and for curing purposes.

Cause of Decomposition.—Fresh fish from its essential nature is a foodstuff which very readily undergoes decomposition and putrefaction; and it is now well understood, and capable of easy demonstration, that these processes are associated with, and chiefly caused by, micro-organisms which are universally present. It is also well known that the three chief factors which facilitate or inhibit the action of the micro-organisms are (1) the supply of nourishment, (2) the temperature, and (3) the degree of moisture.

Structure and Chemical Composition of Flesh of Fish.—Further, the structure and chemical composition of the muscular tissue in fish are such as to facilitate the easy invasion of bacteria and the early onset of decomposition. With regard to the structure we find that in mammals the red variety of striped muscle predominates, whereas in fishes it is the pale variety that is general, and the latter exhibits a lower grade of differentiation than the former. In pale muscle the striations are less regular and the fibres much more readily break up into smaller filaments, and these again into discs. The fibres are not so much bound into separate and strong bundles as in the red muscle in mammals, those which subserve locomotion being simply separated from each other by delicate connective tissue septa. It may also be noted that pale muscle is slightly less vascular than the red.

When we consider the chemical composition of fish we find that the various edible fishes differ less amongst themselves in composition than do the meat foods. But it has to be noted that there is considerably more refuse matter, such as skin and bones, in fish than in other flesh foods, and that this refuse matter contains considerably less water, proteids, fats, and salts than are found in the edible parts of fish. The following table showing the composition of edible fish, beef, mutton, and pork is compiled chiefly from the excellent works of König, Voit, and from the Reports of the Massachusetts State Board of Health:—

	Approximate Percentage Composition of								
	Edible Fish.		Beef.			Mutton.		Pork.	
	Mackerel.	Haddock.	Fat.	Medium.	Lean.	Fat.	Lean.	Fat.	Lean.
Water, . .	72	82	53	72	76	53	76	47	72
Proteids, .	19	17	17	21	21	17	17	15	20
Fats, . .	8	·3	29	6	2	29	6	37	7
Inorganic Salts,	1·5	1·5	1	1	1	1	1	1	1

Water.—From this table we see that the percentage of water found in fish is greater than in beef, mutton, and pork. In the mackerel group the average is 72, in the haddock group it is between 80 and 85 per cent.

Proteids.—With regard to proteids the total quantity present under the various headings is fairly constant, and varies little in the different meat foodstuffs. But there is some difference as regards the variety of the proteids present. In fish, from 4 to 5 per cent. of the proteids consist of the albuminoid gelatine-yielding collagen, which is convertible by boiling with water or treatment with acids into gelatine. There is also much less hæmoglobin or allied colouring matter in the flesh and blood of fish than in meat, which accounts for the white colour usually characteristic of the former. The distinctive colour of the salmon and some other varieties of fish is usually due to fatty animal pigments of the lipochrome series, which are not of a proteid nature. Fish are also poorer in extractives, the chief of which are creatin, creatinin, and xanthin. To the presence of these amido-bodies in meat is due the well-known stimulating effect of meat extracts and beef-tea, which, possessing little actual food value, act as a stimulant through the nervous system in a somewhat analogous manner to tea and coffee. Hence fish, through its gelatine-yielding collagen, is excellently suited for soup-making, but because of the absence of extractives does not make good fish-tea.

Fat.—The amount of fat present sharply divides the mackerel group from the haddock group. The former are spoken of as fatty or oily fish, the latter as lean fish. Halibut and mackerel contain about 5 per cent., herring 8 per cent., salmon and turbot 12 per cent., and eel 18 per cent., whereas none of the fish in the haddock group have more than 2 per cent. of fat.

Hence the constituents fat and water appear to form a sort of inverse ratio—the more of the one present the less of the other. This also holds for the other flesh foods. The fish in the haddock group are comparatively free of fat, but contain a much larger proportion of water. In the mackerel group the proportions of fat and water are not so materially different from those which exist in other flesh foods.

It has been supposed that not only is the characteristic flavour of different kinds of fish due to the presence of certain constituents in the fat, but that also the proneness of fish to early decomposition may be attributable to the same cause. The former statement may be true, but it has to be admitted that the higher members of the fatty acid series, such as palmitic and stearic acid, have very little smell. The latter supposition is hardly in accord with known facts. The fat of fish is of a soft oily nature, because it contains more triolein, which is liquid at ordinary temperatures, and less tripalmitin and tristearin, which are solid at ordinary temperatures, than the fat of mammals. But the fatty acids, such as palmitic and stearic, which are saturated compounds, and oleic acid, which is an unsaturated compound, are both alike very stable compounds, and are not readily broken up except by strong physical and chemical agents.

Inorganic Constituents.—The inorganic salts in fish exceed that found in mammalian foodstuffs and contain more phosphate salts. If the average quantity found in the latter be taken as 1, that found in fish averages from 1·5 to 2 per cent.

Hence when we compare the edible portion or pale muscle of fishes with the red muscle of mammals, and find that the former has usually less fat and much more water, that the tissues are slightly less vascular and have a looser texture, we are led to conclude that these characters

have some intimate relation with the fact that the susceptibility of fish muscle to the attack of putrefactive micro-organisms and to the consequent decomposition is greater than that shown by mammalian muscle.

Bacteria in Fish.—The question of the presence or absence of bacteria in the blood and tissues of living healthy animals in a normal condition is a subject which has received a good deal of consideration, and regarding which there is some diversity of opinion. Regarding fishes it has been frequently stated that micro-organisms can exist in their blood and tissues, just in the same way as many well-known parasites which make the blood and tissues of fish their habitat.

Concerning the parasites of fish there is no ground for contention. They are numerous, and, so far as discovered, their life-histories and habitats are generally well known. During the past ten years the working out of the sporozoan parasites—especially the causal relationship of the myxosporidia to disease in fishes and that of the hæmosporidia to disease in man—constitutes a brilliant chapter in zoological science.

Regarding bacteria, during the past year I have frequently made microscopic examinations of the blood of different varieties of fish, and although I have occasionally observed rod-like and coccus-like bodies, which were suggestive of bacteria, I have to state that as yet I have not been able to isolate in culture any micro-organisms.

I have also frequently examined, both microscopically and by cultures, the fresh peritoneal fluid of fishes, when removed immediately after death with aseptic precautions. When due care was taken it was very seldom that I found any micro-organisms present, and in such cases one often finds that the fish are not in good condition, or have the appearance of suffering from some disease or injury. Neither in the fresh, healthy, living muscular tissue have I ever found any micro-organisms, when examined in the same way with due precautions. Consequently, I am persuaded that, excluding the gut, micro-organisms do not exist to any appreciable extent in the tissues or body fluids of fish under normal conditions, although it may be possible that, under any abnormal conditions, the tissues may be unable to destroy some of the bacteria which reach them during life; or, since the tissues of these animals have great powers of adaptation, they may become tolerant to some. After death, on the other hand, the tissues of fish offer comparatively little resistance to the invasion of putrefactive organisms. For these are soon found multiplying in great numbers in the gut and in all the body fluids, and gradually penetrate in amongst the surrounding tissues.

Products of Bacterial Activity.—Among the products of bacterial activity are some substances of an alkaloidal nature which are very poisonous and have recently been isolated from decomposing fish. It is found that one class of these alkaloids, to which the name mytilotoxin has been given, acts chiefly on the nervous system, paralysing motor nerves like curara, while another class of these acts chiefly on the digestive organs, causing acute gastritis and enteritis. Hence when one has regard not only to the increasing quantity of fish used as food but also to the susceptibility of fish to decomposition, and to the common arrangements on trawlers whereby the fish caught may remain in an iced condition for from one to two weeks or longer, the detection of the earlier stages of decomposition in fish is a matter of the highest importance.

Bearing on Public Health.—This appeals most to public health authorities, whose concern is the public health, and especially to the inspector of meat. His task of examining fish, for the purpose of determining their condition and estimating their position between the

extremes of perfect freshness and putridity, must often impress him with the truth of the adage, "Appearances are deceptive." When fish are seen newly caught, or when putrefaction is pronounced, the appearances in each case are sufficiently characteristic and definite. But between these extremes, and especially in the incipient stages of decomposition, the question is often one of great difficulty and doubt. Here the usual tests employed are very arbitrary, and it is impossible to fix any standard to which all would agree. When a fish has reached the stage of putridity, any ground for contention disappears.

It was in consideration of the above-mentioned difficulties that the following observations and experiments were made, with the view of determining the value of the more common tests applied in examining fish, and, if possible, to find any others more readily applicable and reliable. The fish experimented with were haddocks, whitings, lemon soles, plaice, dabs, cod, and herrings.

The method adopted was to procure both line-caught and trawl-caught fish by pre-arrangement with reliable fishermen, who carefully noted the time and place of capture. The fish on landing were laid out on trays. Some were washed daily with sea water and kept covered with a damp cloth, in such conditions as might prevail in a fishmonger's shop, while others were subjected to different methods of treatment. The temperature was carefully noted from day to day, as the fish were always kept at the ordinary atmospheric temperature.

2. Criteria to be Considered.

I will now discuss *seriatim* the various points as usually alluded to in the examination of fish:—

I. General appearance of fish.
II. The firmness, softness, etc., of the fish when handled.
III. Appearance of surface and scales.
IV. Appearance of eyes.
V. Appearance of gills.
VI. Smell.
VII. Discoloration on ventral aspect of backbone.
VIII. Rigor mortis.
IX. Manner in which the flesh strips away from the backbone, or the bone away from the flesh.
X. The appearance of the abdominal walls, as affected by the gut.

3. General Appearance: Handling a Fish.

Experience soon teaches one that in many cases it is extremely difficult, or even impossible, to determine by appearance alone whether any given fish is or is not fresh and fit for human food, and in this respect there are many possibilities of error. This is often the case with trawled fish which may have been dragged for some time in the trawl net over a muddy or rough sea-floor, subjected to great pressure in hauling the net, or that have been imperfectly iced. The body region of such fish usually presents a very battered and limp appearance, while the head shows more or less extravasation of blood. They may look unsaleable and quite unfit for human food, though, if they are examined more closely, they may be found quite fresh and wholesome. On the other hand, one finds not infrequently in the case of flat-fish that their tougher skin and firmer texture give them the deceptive appearance of being quite

firm and fresh, while closer examination shows that the tissues are saturated with sour-smelling ferments and in the earlier stages of decomposition.

4. The Firmness, Softness, etc., of the Fish when Handled.

One carefully notes the presence or absence of rigidity—especially towards the tail region, where it generally persists longest. If it is present, it stamps the fish as perfectly fresh, and they will be found to be firm and elastic to touch and to slight pressure between finger and thumb. If it is absent, then the fish are not quite fresh. Instead of being firm and elastic they become soft and inelastic, and very soon pit readily and deeply on moderate pressure. Their fitness or unfitness for human food has to be decided by other considerations. There are also certain very definite chemical changes, which take place as muscle passes from the fresh to the putrid condition, and which can be readily detected by litmus paper. But this subject will be discussed in detail subsequently under the heading of "Rigor Mortis."

5. Appearance of Surface and Scales.

One readily observes the imbricated arrangement and disposition of the scales, with their silvery, iridescent, and golden sheen below the lateral line, and paler olive colour towards the dorsum, when a fish is seen newly caught and perfectly fresh. This appearance is, however, only of hourly duration, and the lustre disappears long before decomposition ensues. But more important is the general firmness or looseness of the scales. In the fresh state the scales have a certain degree of firmness, and hence when one finds that they rub off readily, it certainly indicates that the fish are not quite fresh. If, on the other hand, the surface presents a patchy appearance, it often indicates that the fish have been trawled or roughly handled. This appearance, combined with a good deal of blood extravasation about the head region, is very characteristic of trawled fish.

6. Appearance of the Eyes.

This readily appeals to most people in examining fish, but it has a very limited value. In the newly-caught and fresh fish, the full and prominent eye, with jet black pupil in most fish, and transparent cornea, is a very prominent feature. In whatever condition the fish is kept these appearances are very brief. For in 24 hours, in most cases, one can detect commencing opalescence in the cornea, with a lack-lustre appearance of the pupil, and usually in 48 hours slight hollowing of the eyeball is seen. These changes gradually become more intensified, and by the third or fourth day the eyes are grey and shrunken.

7. Appearance of Gills.

This is a time-honoured criterion, and although a good one, yet it is not an absolutely safe guide regarding the condition of a fish. In fresh fish the colour of the gills is described as bright red. This may be a good generic term; but in haddocks and whitings, although the ground colour is red, it is not a deep red. There is present a quite characteristic pale reddish tint, whereas in the herring it is a darker red or brownish-red tint. Thus different varieties exhibit different tints, with red as a ground colour. Now, in every case, in about 24 to 36

hours, the gills in all varieties of fish begin to lose their reddish tint and gradually become grey and slimy. This always occurs by the third or fourth day.

There are, however, certain points which have to be kept in view. In examining quantities of fresh fish, one meets frequently with some which have paler gills than their neighbours, and yet are perfectly fresh, and it is remarkable that in many cases the gills retain with little diminution—especially if washed daily with fresh water or salt water—their characteristic tints, even when the fish has become putrid. It should also be noted that the gills of trawled fish at time of capture, more especially if they have been dragged in the trawl net for some time, are usually of a paler colour than line fish at time of capture.

8. Smell.

So long as fish are fresh they retain their characteristic but not disagreeable odour; but when fish begin to decompose through bacteria activity new substances are formed which are often characterised by disagreeable penetrating odours, and often the escape of these volatile bye-products is the first warning that decomposition has set in.

There are two stages in the history of a fish on the highway to decomposition concerning which all will agree. First, when the odour is perfectly fresh and natural, and, secondly, when the odour is putrid. In the former condition the fish are fit for human food; in the second condition they should be unhesitatingly condemned. But there is an intervening period between these extremes, and here it is the daily experience of those engaged in the examination of fish, that it is often very difficult to interpret these odours correctly as regards the indications which they may give concerning the condition of a fish and its subsequent fitness or unfitness for human food. It is in this intermediate stage that there is room for contention and disagreement.

Regarding this subject I have made the following observations:—

(1) That in every case unwashed fish give off an offensive odour sooner than washed fish. Hence, in smelling an unwashed fish an offensive odour might be derived from decomposing slime lying on the surface, although the fish itself may be quite fresh.

(2) If fish are washed daily with sea water, or even tap water, the development of an offensive odour is considerably retarded.

(3) Ungutted fish soon develope a very disagreeable odour from the decomposition which rapidly ensues, especially in the gut, and to a less extent in the liver.

(4) If fish (gutted or ungutted) in the incipient stage of decomposition, and giving off a slightly-tainted odour, are thoroughly washed in sea water it is remarkable how they are freshened. The tainted odour is expelled and for a time they may again smell quite fresh.

(5) Trawled fish are comparatively free from slime when taken on board, because they have been dragged along for some distance through the water at a considerable speed and most of the slime washed off. But such fish when removed from ice soon begin to give off a tainted odour, because decomposition generally sets in earlier than in line fish.

(6) To test a fish fairly it is always necessary to find out whether the smell is due to the flesh, or to the skin, or to the slime, or to all combined.

Regarding the odour given off as a criterion for purposes of meat inspection, one has always to keep in view that the sense of smell is differently developed in different individuals, and that it is impossible to

set up any exact standard of smell. The different terms used, such as fresh, tainted, putrid, etc., can only have a relative value, although a general standard is always understood. Still, it appears to me that it is possible to place the more common edible fishes into two groups, the one containing the haddock, whiting, turbot, halibut, plaice, and dabs, etc., the other containing such as the salmon, eel, herring, etc. The members of these two groups possess a very characteristic odour when removed from sea water. The former may be described as fresh, fishy, and sea-weedy; the latter as fresh, fishy, but oily.

The time taken before the fresh, fishy odour becomes tainted, stale, and finally putrid depends, as already stated, on the degree in which the media, the moisture, and the temperature are suited for the multiplication of the bacteria of putrefaction. The processes follow along perfectly definite lines, and are the same for all fish.

In the case of washed, ungutted haddocks and whitings, experimented with during last July and August, I invariably found the fresh, fishy odour beginning to be tainted after 48 hours. With washed, gutted haddocks and whitings a longer time elapses before the tainted odour begins to be appreciable, but on an average it is marked at about 60 to 72 hours, and by 84 hours it is distinctly putrid. As regards herrings, the time of appearance of tainted odour appears to be more variable; in some cases after 33 hours, in others not until about 50 hours, but, on the whole, it is earlier than in the case of most white fish.

9. Reddish Discoloration of Ventral Aspect of Backbone.

In all the fish examined, there appeared with striking regularity a reddish-brown discoloration on the ventral aspect of the backbone, usually between the second and third day in the case of line fish, and, on the whole, earlier in the case of trawled fish. It is best seen in the region extending from the kidney to the tail. The kidney itself is a diffuse reddish organ, lying on the ventral aspect of the anterior region of the backbone. It is very friable, and after death readily disintegrates to form reddish debris in this region, but it is not to be confused with the reddish discoloration round the vertebral column, which has a different origin and a different significance.

The earliest appearance of this thin red line in line-caught fish was about 48 hours after capture. It gradually increases in size from $\frac{1}{8}$-inch to $\frac{1}{4}$-inch in diameter during the following 12 hours, and is usually well seen after 60 to 72 hours. Occasionally it was observed in trawled fish before 48 hours after landing, and, on the whole, it appears earlier and develops quicker than in line fish.

The regularity of this appearance suggested a daily microscopic examination of the blood in order to ascertain if there were any changes taking place in it which in any way might be correlated with, and which might be considered explanatory of, the reddish discoloration.

Taken from the fresh fish, the red corpuscles are seen to be flat, slightly bi-convex, oval bodies, with a reddish-yellow colour, showing prominent nuclei and nucleoli. The white corpuscles show no special feature. Occasionally a body will be seen which appears to contain encysted sporozoa, and occasionally a slender, sometimes a thick, rod-shaped bacillus-like body, or a few coccus-like bodies may be seen lying in the serum. On the second day the red cells generally show a breaking-up of their contents. The cell-wall in many cases shows dimpling and creases, while in others the cell contents shrink away from the cell-wall, leaving clear spaces, and a few bacilli may be seen in each field. On the

third day—that is after 60 hours—the blood presents the appearance of an amber-coloured field. The corpuscles have nearly all broken down and their contents have escaped. In each field there will now be seen many micro-organisms, some of which are motile, and a few fragmentary corpuscles. The blood for examination was always taken from the cardinal vein in the caudal region, but on the third day the fluid in this vessel was very scanty.

The discoloration of the tissues, which produces the appearance of a reddish-brown ventral line, will be observed to commence circumjacent to the caudal vein, and inferior to the vertebral column. It then spreads outwards and round the vertebral column, staining the adjacent muscle, until there is a column of tissue from $\frac{1}{4}$-inch to $\frac{1}{2}$-inch in diameter discoloured. If the muscular tissue round the vein be examined from day to day the commencement and progress of the staining of the muscle fibres is readily seen, and by the third day (60-72 hours) micro-organisms are readily detected amongst the tissues, although none will be found in the tissues immediately after death, when examined with proper precautions.

These examinations were made by both wet, dried, and stained microscopic preparations, and by ordinary culture media. An account of the extended bacteriological examination of the nature and properties of these micro-organisms will be given elsewhere.

From these investigations it appears that the micro-organisms present in the blood before death, as also those that gain entrance after death, multiply rapidly in the blood, which forms a suitable nutrient medium, while at the same time the red blood cells disintegrate, and their colouring matter or hæmoglobin is set free. Both micro-organisms and colouring matter soon make their way through the wall of the blood vessel. The former can be detected among the tissues, while the latter causes the reddish-brown staining of the tissues and forms the red streak along the ventral aspect of the backbone. It will be noticed that this staining does not increase beyond certain limits as putrefaction proceeds, the reason being that the blood is limited in quantity, and therefore in its staining powers. These changes occurred in all the fish examined, such as haddocks, whitings, cod, herring, plaice, etc., and they occur in gutted and ungutted fish alike.

The chief value of observing the presence, degree of development, or absence of this sub-vertebral red streak is that it indicates fairly accurately the length of time since the fish were captured or landed. Recently in some fishing districts it has been attempted to remove the sub-vertebral blood vessel along with the gut at the time of capture. In the fish trade, haddocks with well-marked red discoloration will not readily sell as fresh fish, and are usually cured. When cured, the red discoloration is still present, and such a fish will be slightly sour to taste and smell, and its keeping properties are impaired.

10. Rigor Mortis.

The study of rigor mortis in fish is a subject of no less importance to those engaged in the inspection of fish in the interests of public health than to trawl fishermen and fishcurers, who are so often concerned in the preservation of fish as long as possible in the fresh state.

Physiology teaches, and it is a matter of simple experiment, that muscular tissue retains its property of irritability, and will therefore respond to stimuli for some time after the death or destruction of the brain and the cessation of all voluntary movements. The stimuli may be

mechanical, as pinching, cutting, etc., or electrical, such as may be produced by a galvanic cell. This is well seen in the lower vertebrates, such as fish and amphibia. Since the muscles of cold-blooded animals such as fishes are not so closely under, nor so dependent on, cerebral control as those of warm-blooded animals, and since in them metabolic changes are not so active, they exhibit a greater vitality after death as a whole, and retain their property of irritability longer than in higher animals. As rigor mortis can only supervene after the complete cessation of irritability, it is consequently later of appearing and longer of disappearing in these animals than in mammals and birds. As the due appreciation of these facts would be invaluable to trawl fishermen, fish-curers, and meat inspectors, and since such knowledge could be utilised on the one hand for the better preservation of fish, and on the other for the inspection of fish, the following simple experiments may be readily carried out, and by doing so, an intelligent and practical acquaintance with this subject may be readily obtained.

When a newly-caught fish is taken out of the water, as in rod or line fishing, it leaps and struggles about, often with fins erect, and attempts to get back to its natural habitat. These movements gradually diminish, and usually in from 15 to 30 minutes have ceased, and in five minutes more there is usually no response on handling. The fish is now practically dead, but the muscles still retain their power of irritability for a varying length of time, which may extend from 10 to 15 hours according to circumstances, and still respond in the form of contraction to electrical and mechanical stimuli, which may be produced, on the one hand, by a very simple electrical apparatus, and on the other by simply tapping, pinching, cutting, etc. This property of irritability will be found to disappear first in the muscles of the head region, then in those of the trunk, and lastly in those of the tail region. Then, just in the same order from before backwards, the gradual disappearance of irritability is succeeded by rigidity of the muscles or rigor mortis. It is first seen in the muscles of the lower jaw and gill covers, when the mouth and gill covers are firmly closed. The stiffening then travels backwards until the whole fish is rigid, and, when complete, the mouth is often gaping widely open. After an interval of time, varying from hours to days, the rigor begins to disappear precisely in the same order as it appeared—first the muscles of the jaws and gill covers, then those of the trunk, and lastly those of the tail region, until the whole fish becomes quite soft and limp, just as it was when removed from the water.

Such, in general outline, is the sequence of events; but there are many important factors which exercise a determining influence as regards time of onset, length of duration, and disappearance of rigor in fishes. The most important of these I will state briefly. They are from observations made on a large number of fish, probably several thousands.

The cause of rigor mortis—the coagulation of the soluble myosinogens of the muscle plasma—is not for the present under consideration.

It will be found that rigor is later in appearing and lasts longer in the following conditions:—

A. Fish in season.
B. Fish in a healthy and vigorous condition.
C. Fish which are at once killed on capture.
D. Fish which are not only killed but are pithed at the same time —that is, have the brain and spinal chord destroyed.
E. Fish gutted immediately on capture.
F. Fish handled as little as possible after capture.
G. Fish kept at low temperatures, as when iced or kept in cold storage.

On the other hand, rigor appears earlier and disappears sooner in the following conditions:—

A^1. Fish not in season.
B^1. Fish in an exhausted condition.
C^1. Fish not killed at time of capture.
D^1. Fish neither killed nor pithed at time of capture.
E^1. Fish ungutted.
F^1. Fish roughly handled.
G^1. Fish not iced and not kept at low temperature.

It is also to be observed that rigor tends to persist longer in those varieties of fish, such as salmon, whose muscular tissue is firmer in texture and contain a smaller percentage of water than in most varieties of white fish, such as whitings and haddocks, where the tissues are not so firm and contain more water.

From these observations we must conclude that the degree and duration of rigor in fish depends chiefly on the condition of the muscular tissues at time of death. The more the conditions at time of death approximate A, B, C, D, E, F, G the later will rigor set in—sometimes not for 10–30 hours—and it may persist 1–3 days. whereas the more exhausted the fish is, when conditions A^1, B^1, C^1, D^1, E^1, F^1, G^1 obtain, the sooner rigor appears and disappears. Sometimes it is even difficult to detect.

The cause of the disappearance of rigor in muscle is a question regarding which all are not agreed. True it is that, in muscle in condition of rigor, the conditions for pepsin-digestion are present. The muscle is acid, and pepsin ferment, although in a very small quantity, is also present. Still it appears that although pepsin-digestion may play some part in the initial stage, it is a small one, and that the chief and final cause is due to bacterial invasion. It is very rare to find any micro-organisms in muscle during rigor, but as rigor passes off they increase rapidly.

As already stated, to preserve fish as long as possible in rigor, conditions A, B, C, D, E, F, G have to be observed, and in practice the most important is G—the maintenance of low temperature.

Since it is possible to inhibit the action of most bacteria of putrefaction by maintaining a low temperature from 0°C. to –3°C., while at the same time maintaining the fish in a condition of rigor, it thus becomes possible to preserve fish in a comparatively fresh condition for a considerable time with very little deterioration in their tissues. At temperatures below –3° C. the fish suffer considerably. When such fish are thawed they are usually found to be very soft and limp, and pit deeply on pressure. The lower the temperature the deeper and more extensive the freezing of the water in the tissues, which must cause at the same time a proportionately greater amount of mechanical disintegration. Such fish are more difficult to cure; when cooked they are found to have lost much of their natural flavour, and they very readily undergo decomposition. By maintaining the temperature about –4° C. to 5° C. fish appear to remain in a condition of rigor indefinitely. If the temperature is kept at –5° C., or lower, fish do not appear to pass into rigor, but may be observed to do so on raising the temperature above –4° C.

It has so happened that on some occasions the fish I was experimenting with were kept in a mixture of sawdust and ice. This combination impressed me favourably, and it appears to be more effective in maintaining rigor and inhibiting the onset of decomposition than ice alone The best mixture appears to consist of small lumps of ice, with the intervening spaces filled up with sawdust. Although I have not been able as

yet to experiment very far in this direction, yet I am convinced that this matter deserves consideration and a fair trial by those engaged in the trawling industry,

Further, there is the very important question—What is the best time to ice fish?

A. When rigor is completed?
B. Before rigor has set in?
C. After rigor has disappeared?

In the trawling industry the process of icing is so extensively practised that the degree of freshness when put on the market, the suitability for successful curing, and the palatable qualities of the fish in general, may be said to depend on proper icing. Consequently, this is a subject which deserves more consideration than it has hitherto received. But as this part of the investigation is not yet complete, and as many enquiries are in hand as to the conditions of icing observed in trawling, I will only note a few more or less provisional conclusions.

The observations which I have made during the past few months have been chiefly on haddocks and whitings.

Some were gutted and some left ungutted and immediately placed in ice, under conditions A, B, C. The fish were selected from line boat catches, and three sets of experiments were made, as in following Table :—

	A. Rigor completed.			B. Before rigor set in.			C. Rigor disappeared.		
Fish used.	1st.	2nd.	3rd.	1st.	2nd.	3rd.	1st.	2nd.	3rd.
Haddocks, gutted, -	6	5	4	6	6	3	6	6	3
Haddocks, ungutted, -	6	5	4	6	6	3	6	6	3
Whitings, gutted, -	4	5	4	6	5	3	4	6	3
Whitings, ungutted, -	4	5	4	6	5	3	4	6	3

Some of each variety were placed in ice when rigor was completed (condition A), others were iced immediately after death before rigor had set in (condition B), and those of a third lot were iced at various periods (1–10 hours) after rigor had passed off (condition C).

Then some of each lot, A, B, C, were removed at intervening periods of 5, 10, 15 days afterwards, examined and treated so as to ascertain their qualities as regards keeping, curing, and palatability.

In each respect those preserved under condition A were found to be distinctly the best; in the second degree came those preserved in condition B; while those preserved under condition C were poorest.

In regard to those iced under condition C (1–10 hours after rigor had passed off), it was found that in proportion to the number of hours before icing was the rapidity of decomposition when removed from the ice.

11. Detection of Rigor Mortis.

When rigor is strongly and fully developed its presence is easily detected. The fish is quite rigid or nearly so according to the degree of rigor, which again depends on conditions already discussed. When one balances such a fish on the finger it may remain quite rigid, but when rigor is beginning to pass off it may begin to droop at head or tail or both. Here it is often difficult to be certain about the condition, and especially when rigor has not been well developed. But when rigor is passing away one will observe that the fish, from being firm and elastic to the touch, becomes softer and inelastic and pits readily on pressure. The chemical changes are always fairly definite during these transitions. Preceding rigor, while the muscles are irritable and respond to stimuli, their reaction is neutral or faintly alkaline. During rigor they are strongly acid. As rigor passes off they become neutral. Then as decomposition ensues they become strongly alkaline when tested with litmus paper.

This part of the subject has been discussed in considerable detail, and the reasons for this must be stated. We have found, on the one hand, that those who have to do with the preservation of fish in the fresh state have not given the subject due consideration, nor recognised the great commercial value, and yet it is the initial and most important stage in the process of fish preservation ; and we have found, on the other hand, that this subject is often inadequately understood by those whose duties are to examine fish in the interests of public health. They likewise fail to take advantage of an invaluable criterion, which, when present, stamps fish as absolutely fresh, or, if absent, points to ensuing putrefaction and decomposition.

12. Trawl Fish compared with Line Fish.

Since the advent of the great trawling industry the question has often been discussed as regards the general condition, curing properties, and keeping properties of trawl fish as against line-caught fish. But, at the present time, opinion is very much divided.

Professor MacIntosh, in an Appendix to the Report of the Trawling Commission, 1885, states that the general condition of trawl fish is excellent and that they become rigid like line-caught fish, whereas, on the other hand, it is the experience of many fishcurers that it is often difficult to cure such fish, especially as findon haddocks.

I have examined many lots of fish taken from the trawl net after being a certain number of hours at work and treated under different conditions. Some were killed when taken out on board, some not killed, some gutted, and some ungutted. When such fish are compared with line fish under similar conditions, it will be found generally that rigor sets in earlier and disappears earlier in the trawl fish.

The reason for this is evident when one considers the conditions under which fish are trawled. The longer the fish remain in the trawl net the more do they become crowded together, while the motion of the net through the water maintains a certain degree of compression. Respiration is consequently impeded while the fish are struggling to respire and to get freedom. Trawled fish are also subjected to considerable pressure while the net is being brought on board. The result is that the tissues are not sufficiently oxygenated, waste products accumulate, and the fish become more and more exhausted the longer they remain in the trawl net. Fishcurers frequently observe this condition in herrings which have been

caught under similar conditions and speak of them as "drowned herrings," since many of them are found dead when taken on board. These are always difficult to cure. It will be frequently found, however, that in examining a catch of trawl fish many of them pass into a condition of rigor and behave under treatment just like line fish. These may have been only a very short time in the trawl net, and some may have been captured when the net was being hauled on board.

From these investigations we must conclude that trawl fish, since rigor sets in earlier and disappears earlier, which fact allows the earlier onset of decomposition, are neither equal to line fish in general conditions, nor in curing properties, nor in keeping properties, except when the fish have only been a short time in the trawl net.

The above statement compares trawl with line fishing only so far as they are comparable, and takes no account of the process of icing fish.

13. Manner in which Flesh Strips away from Backbone, or Bone away from Flesh.

When fresh fish are examined from day to day it will be found that during the first day it requires considerable pressure by finger and thumb to separate flesh from bone, or to strip bone from flesh, and in doing so many tags of flesh are left adhering to the bone. By the second day, although rigor mortis will generally have disappeared and softening commenced, due to early stage of decomposition, yet there may not be much difference as compared with the first day. But from many observations made, it was generally found that by the third day the flesh is much more friable and soft, and separates from the bone with moderate pressure. By the fourth day the flesh will generally be found to be soft and pulpy and to strip off readily and cleanly, leaving very few tags adhering to the bone. On the fifth day the flesh and bone separate from each other readily and cleanly.

When gutted and ungutted fish are compared together in this respect, it will be found that the difference in time when the fish in both strips off alike is not so great as one might expect, although it is certainly longer on the whole in the case of the former. This is a very valuable test, but for its due appreciation some care and practice is required.

It is difficult, however, to attempt to set any precise time limit beyond which the fish should be condemned by this test. The times stated above are an average, but will be found fairly accurate in practice. One must judge by the degree of pressure required, and the degree of cleanness of separation. When the flesh comes away readily and cleanly with little pressure, one usually finds other confirmatory signs and has no hesitation in at once condemning such fish.

14. The Appearance of the Abdominal Walls as Affected by the Gut.

The part played by the gut is one of the chief factors in initiating decomposition in fish and possesses considerable interest. If ordinary white fish, such as haddock or whiting, line-caught and ungutted, be laid out and kept moist for experimental purposes and examined from hour to hour, it will be found that the wall of the gut in almost every case is the first part to undergo *post-mortem* changes and solution. This will sometimes be observed to take place before rigor mortis has set in, and very frequently before rigor has passed off. It is a question round which

there has been much discussion, whether this solution of the wall of the gut is due to the digestive action of intestinal ferments or to putrefactive processes. But when one has due regard to the rapidity in many cases with which solution of the gut wall takes place, it appears to be at least initiated by *post-mortem* digestion, although this process may be accompanied by, and is certainly soon superseded by, the action of the bacteria of putrefaction which abound in the gut.

There are, however, certain factors which appear to hasten or retard this process. It will always be found to take place sooner in fish which have been feeding immediately before capture. Amongst the fish under examination, one frequently finds, especially in dealing with herring or cod, some whose stomachs were evidently packed with crustaceans or small fish at time of capture, and in these cases digestion and solution of wall of gut may take place in a few hours, whereas if the gut is comparatively empty the digestion may be considerably delayed. This certainly takes place very rapidly in herring in the above condition, and I have frequently observed it in herring in the spent condition. It has frequently been observed by fishermen that herring with stomachs packed full at time of capture very rapidly undergo putrefactive changes, and often have been useless for curing purposes before being landed.

It occurred to me that possibly the kind of food might exercise some influence in determining the earlier or later onset of decomposition in fish. Accordingly I examined the stomach contents of a considerable number of fish, as well as consulted the excellent papers that have appeared in the reports of the Fishery Board for Scotland by Dr. W. Fulton, Director of Scientific Investigations, Dr. T. Scott, and those of other writers. But it appears to me that many fish, although they may have some predilections for certain kinds of food, are on the whole indiscriminate feeders, and that the kind of food partaken of is determined chiefly by the habits and disposition of the individual fish and the condition of hunger at time of feeding. One generally finds the principal food in the stomach of the haddock is crustaceans. Whitings, on the other hand, are rapid and agile swimmers, with keener eyesight. They hunt their food, and one finds that it consists chiefly of young herrings, sand eels, and small flat fish. Cod are voracious eaters and appear to feed on crustacea and smaller fish. But, on the whole, more of the former were found in their stomachs than the latter, and it is possible that they prefer the former to the latter when it is readily accessible. As regards saithe, I found that in the adult fish the stomach contents consisted of mixtures of herrings and many varieties of smaller fish. But the younger the saithe the more they seem to prefer crustacea.

Herrings appear to feed largely on crustacea and sand eels. I also examined the stomach contents of a few other varieties of fish, but it appeared evident that no very definite conclusions could be formed from this line of enquiry, since fish do not adhere to any one class of food, and that what they eat depends chiefly on the exigencies of circumstances as stated above. However, in order to control the conditions of feeding and make this enquiry more precise, I obtained a small cargo of haddocks freshly caught, brought ashore in sea water and transferred at once to tanks, where they were kept in conditions approaching to their natural habitat. After a few weeks, when acclimatised and feeding readily, separate lots were fed for a few days on such foods as bread crumbs, pieces of fish, and crustaceans. Then, on a certain day, so many were taken from each tank at different times after feeding and killed, some at 15 minutes, one hour, two hours, etc. These were laid out in plates and kept moist, and observations were made from hour to hour.

From a large number of observations I came to the conclusion that the kind of food in the stomach exercises some, but not an important, influence on the time when decomposition sets in and the rate of its progress. In the fish fed on carbo-hydrates, digestion of the wall of the gut, when it did take place, was slower than in those fed on proteid foods, and on the average decomposition was slower in appearing. Still, it has to be kept in view that very few edible fish in their natural habitat feed on carbo-hydrates, so that this observation does not possess much practical value.

Far more important, however, as regards the onset of decomposition, is the time after feeding when the fish are killed. Invariably, in those killed from 15 to 45 minutes after feeding, *post-mortem* digestion appeared to be more active. Consequently, in a greater number of these, digestion and solution of gut wall took place sooner than in those killed at a later period of from one to two hours after feeding. This observation is in accordance with Pawlow's experimental work on gastric secretion and digestion—that increase in quantity of food, and especially proteid food, causes a more active secretion of gastric juice, and that the secretion is more abundant in the earlier stage of digestion, or soon after the ingestion of food.

This part of the enquiry, however, must be studied in a wider and more natural field than within the confines of the laboratory. Here the environment is so different to that which obtains in nature, and to which fish do not become readily acclimatised. I have often discussed this question with intelligent and observant fisher people, who assure me that the keeping, curing, and edible qualities of fish vary greatly with the nature of the ground on which they have been living and feeding. So much so is this the case that they associate soft ground with soft fish and hard ground with hard fish, and map out large areas of fishing ground accordingly. They are of opinion that the foodstuff obtained on the soft ground consists chiefly of worms and small fish, while that obtained on the hard ground consists largely of crustacea, and this to a certain extent agrees with my own observations. This statement is also in agreement with the experience of many fishcurers, who tell us that soft fish do not keep so long fresh and are more difficult to cure.

Then there are what is known as "spawny haddocks." These have been feeding for some time on herring spawn at certain seasons of the year. Now, fishermen and curers inform me that such fish are very difficult to keep fresh, and show early signs of decomposition. Hence it is possible that the food of fishes differs in kind and quality in different parts of the sea and at different seasons of the year in such a way that it has some influence in determining not only the earlier or slower onset of decomposition, but also the quality of the flesh of the fish and its curing and edible properties.

As one would expect, temperature plays a very important part in all processes of putrefaction and decomposition in fish. At freezing point, it is supposed, these processes are, if not destroyed, at least inhibited. But I find that fish ungutted and packed in ice, when removed from the iced condition, always begin to exhibit commencing signs of decomposition earlier than fish which have been gutted immediately on capture and then packed in ice. Hence it is quite possible that the degree of cold produced by icing fish, as it is generally carried out on board trawlers, may not altogether inhibit fermentative changes taking place in the gut.

From these observations I conclude that the chief factors concerned in determining the rapidity of *post-mortem* digestion and solution of the

wall of the gut, and the rate of progress of ensuing putrefactive changes in the gut and the adjacent abdominal walls, are :—

(1) The quantity of food in the stomach at the time of capture.
(2) The quality or kind of food in the stomach at time of capture.
(3) The temperature at which the fish are kept.

After solution of the gut wall the intestinal ferments and bacteria pass out at once into the peritoneal cavity. But even if the fermentative processes are inactive and solution of gut is delayed, the intestinal juices and bacteria gradually pass out through the dead membrane into the peritoneal cavity, and the ultimate result is the same in both cases. This process is readily followed by making cultures and microscopic examination of the peritoneal fluid. Occasionally, in making microscopic preparations of fresh peritoneal fluid, I observed what appeared to be possibly rod-shaped bacilli. But on further examination of this fluid obtained immediately after death with aseptic precautions by searing the abdomen and withdrawing it by sterile platinum wire, then inoculating bile-salt glucose peptone litmus solution, and plating out on Conradi and Digralski media and making subcultures when necessary on appropriate media, I found that in most cases the cultures gave negative results for the bacillus coli. In over 100 such experiments there were only in the case of six fish presumptive evidence by the MacConkey media of the presence of the colon bacillus. But on plating out, and by subcultures, it was found that two of these cases gave negative results. In three of them atypical coli-like organisms were present, and in two cases strepto-cocci were present.

In consideration of these results, as well as those obtained by others regarding man and the higher animals, we must conclude that the peritoneal fluid in healthy living animals is normally sterile. That when otherwise and micro-organisms are present there is probably always some causal condition of disease or traumatism. However, it is remarkable how soon after death one will find micro-organisms in it. In examining the peritoneal fluid by the above method, I have frequently found bacillus coli in about 45 to 60 minutes after death, and in a very few cases even 30 minutes after death. After one hour they will be found readily in greatly increasing numbers.

The functions of the peritoneum are subjects around which there has been much discussion. But bacteriologists are now agreed that during life the peritoneum exercises a strong protective influence against intruding bacteria. After death, the power being lost, the intestinal ferments and bacteria pass through it very rapidly and come into close contact with the muscular tissue of the abdominal walls, which usually in a few hours thereafter begin to exhibit a series of changes which are very marked and definite. First, the surface of the muscles, and especially those near the neck, which form the "lugs," begin to show a delicate pinkish tint which gradually deepens to a reddish brown, and finally to a dark yellowish amber or apple-jelly colour. Simultaneously, as rigor mortis passes off, the muscles begin to soften, and this softening of the inner surface of the thinner parts of the abdominal walls, combined with the above-mentioned discoloration, is spoken of in the fishcuring trade, in the case of the haddock, as "jelly lugs." If this condition is well advanced the fishcurer knows that such fish are not fresh, and often they are difficult to cure, especially as findon haddocks.

If this pulpy, apple-jelly-like material be examined microscopically, it will be found to consist chiefly of muscle fibres considerably swollen, breaking up into discs, and in process of disintegration. Of the numerous

bacteria always present, the bacteria coli is not infrequent, and is readily detected in cultures, especially on the Conradi and Digralski media.

In some cases these processes go on so rapidly that there may be complete digestion of a part of the abdominal wall in 36 hours, or even less, after death. In 48 to 72 hours it may occur in about one-half, and in very few will the abdominal wall remain intact after 96 hours.

Undoubtedly, as rigor mortis passes off, this process of auto-digestion in the gut and in the surface of the adjacent abdominal walls is early accompanied by, and soon finally superseded by, putrefactive processes, the presence of which is readily detected by:—

(1) The softening and apple-jelly appearance of the abdominal walls.
(2) The increasing stale odour, becoming offensive and finally putrid.
(3) The reaction of the muscles, becoming alkaline to litmus paper.
(4) Sometimes in ungutted fish the presence of hydrogen sulphide can be detected.

At this stage bacteria are always present and can be detected either by direct microscopic examination or very readily by making cultures from the tissues.

The above statement has reference chiefly to ungutted fish. The removal of the gut immediately after capture, or at least soon after capture, will to a considerable extent preclude the process of auto-digestion. Consequently, the abdominal muscles remain longer firm, and discoloration, with its accompanying softening and putrefaction, are delayed. The micro-organisms present in cultures from the softening abdominal muscles will also differ from those in ungutted fish, inasmuch as the bacillus coli will usually be absent.

Ungutted fish during the cold season may keep sufficiently fresh for one or even three days, but if kept longer, whether iced or not iced, the flesh becomes saturated with acrid ferments and exhibit a sour smell. When such fish are cooked they are found to have lost much of their natural flavour. If cured, it will be found that they have lost much of their flavour, and that they do not keep well.

15. The Distribution of the Bacillus Coli in Fish.

For some time it has been well known that, in man, this bacillus is the chief inhabitant of the small intestine, and also in the large intestine it finds a habitat associated with many other micro-organisms. Recently, with the development and more extensive application of sanitary and bacteriological science—especially in the consideration of food and water supplies—this bacillus has been studied more widely in nature, and has now been proved to be present in the dejecta of most, if not of all, mammals; and that, with the exception of some slight difference in culture, in pathogenicity, and as regards fermentaton of the different sugars, there is no essential biological difference between the bacillus coli found in man and in the lower mammals.

It has frequently been attempted to formulate these differences as a basis for differentiation and classification of the bacillus coli found in the intestine of man and those found in lower animals, and to extend its application to the consideration of sewage pollution, water supplies, etc. But, however desirable this may be, in considering many public health questions, in practice it fails, and at the present moment there is no reliable means of distinguishing between bacillus coli derived from animal excreta and those derived from human excreta.

During the past few years this enquiry has been extended to the lower sub-kingdoms—birds, amphibians, and fishes—and of these, fishes have probably received the most consideration on account of their extensive and valuable use as a foodstuff, and because they are the inhabitants of waters from which water supplies are derived.

Houston, in his report to the Royal Commission on Sewage Disposal, with special reference to the contamination of shell fish, states, as regards oysters, and in a later report (1903–04) on the bacteriological examination of the excreta of fish—both oysters and fish derived from deep-sea water remote from sewage pollution—that typical bacillus coli, or even atypical bacillus coli, are seldom detectable in the former, and are absent, or only present in small numbers, in the intestines of fish.

At the same time, the Commissioners had to regret the paucity of our knowledge as to the distribution of the bacillus coli in nature.

Recently Eyre, MacConkey, and Johnson have done a considerable amount of work in this direction. Their results differ from those of Houston in this respect, that they find the bacillus coli almost universally present in the intestinal canal of fish.

During the past nine months, in the intervals of other work, and as opportunity afforded, I have examined the intestinal contents obtained from a large number of different kinds of fish with the view of ascertaining the extent of the distribution of the bacillus coli in fish.

The media used :—

General media:
- (*a*) MacConkey's bile-salt glucose peptone litmus solution.
- (*b*) Digralski and Conradi's nutrose litmus agar, and, to less extent, neutral-red bile-salt agar and lactose litmus agar.

(*a*) *MacConkey's bile-salt glucose peptone litmus solution.*

Sodium taurocholate,	-	5 grams.
Glucose,	- - -	5 grams.
Peptone,	- - -	20 grams.
Water,	- - -	1000 c.c.

The constituents are heated until dissolved, then filtered and sufficient neutral litmus solution added. The medium is then distributed into Durham's fermentation tubes and sterilised by steaming for 20 minutes for three successive days.

(*b*) *Conradi-Digralski agar medium.*

This medium is rather tedious to prepare.

(1) *Agar Preparation.*—To 3 lbs. finely minced horse flesh or minced ox beef, add 2 litres of water, and let stand for 24 hours. Then boil one hour and filter. To filtrate, add peptone sicca and nutrose, 20 grams of each, and 10 grams sodium chloride. Boil one hour and filter. Then add 70 grams bar agar, boil for three hours in koch or one hour in autoclave, render slightly alkaline (using litmus paper), filter, boil for half an hour.

(2) *Litmus Solution.*—Kubel and Tiemann's, got from Grubler, Leipsig, is the best. Take 260 c.c., boil for ten minutes, then add 30 grams pure milk-sugar and boil 15 minutes.

(3) Take solution (2) and add to solution (1) when cooled to 60° C. Shake, render faintly alkaline. Then add 4 c.c. hot sterile solution of 10 per cent. water-free soda and 20 c.c. of freshly-prepared solution of 0·1 gram crystal violet (Hochst) in 100 c.c. warm sterile distilled water.

Particular media for subculture:—

(1) Gelatine slope, stab and shake cultures.
(2) Litmus milk.
(3) Lactose-peptone litmus solution.
(4) Peptone water.
(5) Glucose neutral-red broth.

In this way I followed Houston's "flaginac" basis of classification for bacillus coli:—

Fl.—Greenish fluorescence in neutral-red cultures.
A.G.—Acid and gas in lactose-peptone cultures.
In.—Indol formation in peptone cultures.
A.C.—Acid and clotting of litmus milk.

A microbe which presents these characters in subcultural tests is indistinguishable, as regards the tests employed, from the typical bacillus coli of the human intestine.

Method of Procedure.—The fish examined were obtained at different times and from different sources at the Aberdeen fish market during my visitations—some line-caught, some from trawlers. But the great majority of the fish were not caught at any great distance from the shore, although some were obtained from trawlers from the Iceland fishing grounds.

Each fish was washed in tap water, then in sterile water, and tacked out on a board. The skin on the ventral aspect of the abdomen was thoroughly seared with a red-hot cautery iron, and the stomach and intestines dissected out by sterile instruments. Some of the intestinal contents were then aspirated up into a pasteur pipette or removed by sterile platinum wire to bile-salt glucose peptone litmus in a Durham's fermentation tube and incubated for 48 hours at 37° C., 1–5 tubes inoculated for each fish.

Sometimes the whole gut was removed, washed in tap water, then in sterile water, and the whole contents well mixed with bile-salt glucose broth.

From this emulsion other bile-salt glucose peptone tubes were inoculated with varying quantities. None of the fish were cut up and mixed with the intestinal contents. A positive reaction is shown by the production of acid and gas. The acid turns the medium red, and gas is seen in the inner small tube. But as this reaction is only presumptive evidence of the presence of a member of the coli group, I always plated out on one or other of the solid media—chiefly Digralski and Conradi—and from the colonies on this media, when present, subcultures were made in accordance with the "flaginac" basis.

The following Tables exhibit my recorded results:—

Table I.—Showing the Biological Characters of the Bacillus Coli and Coli-like Microbes isolated from Fish.

		Bile-salt Glucose Peptone Litmus Solution. 48 hours, at 37° C.	Digralski and Conradi. Litmus Agar. 24 hours, at 37° C.	Glucose Neutral-red Broth. Fl.—Greenish-yellow Fluorescence. 48 hours, at 37°C.	Lactose Litmus Peptone Solution. A.G.—Acid and Gas. 48 hours, at 37° C.	Peptone Water for Indol. In.—Indol. 7 days, at 37° C.	Litmus Milk Culture. A.C.—Acid and Clot. 5 days, at 37° C.
				Fl.	A.G.	In.	A.C.
Haddocks - 10 Experiments	4	×	×	×	×	×	×
	2	—	—	. .	. .	. .	. .
	1	—	—	. .	. .	. .	. .
	1	×	×	Fl. sl.	×	×	Ac. Cl. s
	2	×	×	Fl. sl.	Ac. Gas sl.	—	Ac. Cl. sl.
Whitings - 9 Experiments	5	×	×	×	×	×	×
	1	×	×	×	Ac. No gas.	—	Ac. sl. Cl. sl.
	1	—	. .	. .	. .	. .	. .
	2	×	×	—	Ac. Gas sl.	—	Ac. No cl.
Plaice - 7 Experiments	3	×	×	×	×	×	×
	2	×	×	Fl. sl.	Ac. No gas.	—	Ac. sl. Cl. sl.
	1	×	×	Fl.	A.G.	—	Ac. sl. No cl.
	1	× ?	—	. .	. .	. .	. .
Dabs - 8 Experiments	4	×	×	×	×	×	×
	2	—	—	. .	. .	. .	. .
	1	×	×	—	Ac. Gas sl.	—	Ac. No cl.
	1	—	. .	. .	. .	. .	. .
Lemon Sole - 5 Experiments	3	×	×	×	×	×	×
	1	×	×	Fl.	A.G.	×	Ac. No cl.
	1	×	×	Fl.	A.G.	—	A.C.
Shrimps - 4 Experiments	1	×	×	×	×	×	×
	1	×	×	Fl. sl.	Ac. No gas.	—	Ac. sl. Cl. sl.
	1	—	. .	. .	. .	. .	. .
	1	×	×	Fl. sl.	—	—	Ac. sl. Cl. sl.
Dog-fish - 2 Experiments	1	×	—	. .	. .	. .	. .
	1	×	×	Fl.	Ac. sl. Gas sl.	—	Ac. sl. No cl.

Table I.—continued.

		Bile-salt Glucose Peptone Litmus Solution. 48 hours, at 37° C.	Digralski and Conradi. Litmus Agar. 24 hours, at 37° C.	Glucose Neutral-red Broth. Fl.—Greenish-yellow Fluorescence. 48 hours, at 37° C.	Lactose Litmus Peptone Solution. A.G.—Acid and Gas. 48 hours, at 37° C.	Peptone Water for Indol. In.—Indol. 7 days, at 37° C.	Litmus Milk Culture. A.C.—Acid and Clot. 5 days, at 37° C.
				Fl.	A.G.	In.	A.C.
Skate - - 3 Experiments	1	×	×	Fl. sl.	A.G.	In. sl.	Ac.
	1	—	—	. .	. .	. .	. .
	1	—	—	. .	. .	. .	. .
Cat-fish - - 2 Experiments	1	×	×	—	Ac. No gas.	—	Ac. sl. Cl. sl.
	1	—	—	. .	. .	. .	. .
Crabs - - 4 Experiments	2	×	×	×	×	×	×
	1	×	×	Fl.	Ac. sl. Gas sl.	—	Ac. No cl.
	1	×	×	—	Ac. sl. No Gas.	—	—
Cod - - - 4 Experiments	2	×	×	Fl. sl.	A.G.	×	Ac.
	1	×	—	. .	. .	. .	. .
	1	×	×	Fl. sl.	Ac. Gas. sl.	—	Ac. sl. Cl. sl.

Table II.—Summary of Results.

	No. of Experiments.	Typical bacillus coli.	Atypical bacillus coli.	Negative results.
Haddocks, ...	10	4	3	3
Whitings, ...	9	5	3	1
Plaice, ...	7	3	3	1
Dabs, ...	8	4	1	3
Sole, ...	5	3	2	. .
Shrimps, ...	4	1	2	1
Dog-fish, ...	2	. .	1	1
Skate, ...	3	1	. .	2
Cat-fish, ...	2	. .	1	1
Crabs, ...	4	2	2	. .
Cod, ...	4	2	1	1
Total, . .	58	25	17	16
Percentage, .	. .	43	33	24

16. Bacteriological Examination of Fresh Peritoneal Fluid—chiefly for Bacillus Coli.

Method adopted.—The fish were killed immediately after capture, the ventral aspect of abdomen washed, with sea water in the case of some dealt with at sea, with tap water and sterile water in the case of those caught near the shore by line—boat or rod. Then the abdomen was carefully seared with red-hot cautery, and peritoneal cavity opened by sterile knife and three loopfuls of peritoneal fluid withdrawn by means of sterile platinum wire and used for the inoculation of each tube of the following media :—

(*a*) Bile-salt glucose peptone litmus solution in Durham's fermentation tubes.
(*b*) Digralski and Conradi's medium.

Twenty-five experiments were made with the following fish :—Six haddocks, 5 whitings, 2 young skates, 2 codlings, 2 cat-fish, 1 dog-fish, 3 plaice, and 4 herrings.

In 19 cases the results were negative.

In the case of two herrings, one whiting, and one plaice there appeared in the bile-salt medium a very slight trace of discoloration and just a few bubbles of gas. On the Conradi and Digralski medium one of these herring and the whiting gave negative results. From the remaining herring and plaice subcultures were made on various media, but only in the case of the herring were any growths obtained, and from these a strepto-coccus was isolated. It was noted, however, at the time of capture that this herring did not appear to be in a healthy condition. There were several scratches on its sides and patches of scales had been rubbed off. Two of the cases suffered liability to contamination, and are not here considered.

Although from these few experiments one is scarcely warranted nor justified in coming to the conclusion that the peritoneal fluid in fish is a sterile fluid, yet, from the fact that out of 23 experiments (leaving out two spoiled experiments), only four suggested some suspicion, and from only one of which, an ill-conditioned fish, was a strepto-coccus isolated, the evidence of these experiments points to the probability of the peritoneal fluid in healthy living fish as being sterile.

I made a series of observations regarding the time after death when the bacillus coli could be detected in the peritoneal fluid.

About 30 experiments were made at different periods. The fish were killed, laid out on trays, and kept moist. At short intervals the abdomen was opened with aseptic precautions and suitable media inoculated, incubated, examined, and subcultures made.

In about five cases the bacillus coli was detected 40 minutes after death; in about nine cases, 1 hour after death; and from $1\frac{1}{2}$ to 2 hours after death micro-organisms are numerous in the peritoneal fluid.

17. The Bearing of the Distribution of Bacillus Coli in Fish and other Lower Animals on Public Health Questions.

In consideration of the above results, and those of other workers, it is difficult to avoid the conclusion that the coli bacillus, if not a normal inhabitant of the intestinal canal of fish in general—a statement which we readily admit is not yet fully warranted from the above observations —has at least a far wider distribution in fish than was generally anticipated

Although very little work has been done on this subject in this country, the results of Houston and Eyre are interesting and invite comparison.

Houston, experimenting on fish obtained off the Norfolk coast—a locality remote from sewage pollution—found that only 13 per cent. of the cases he examined exhibited typical bacillus coli, 52 per cent. atypical, while 34 per cent. gave negative results. From these results he concludes that, although fish in a sewage-free locality may sometimes contain typical bacillus coli in their interior, it can hardly be the case that even coli-like microbes are present naturally in abundance in fish.

Eyre, working about the same time, and finding the coli bacillus almost universally present in the intestinal canal of the lower mammals and birds, obtained a large variety of fish off the Lincolnshire coast, and had no difficulty in isolating typical bacillus coli from every fish experimented with.

It is thus quite reasonable to suppose that either a sewage-polluted or a sewage-free environment will exercise some influence in determining the extent to which bacillus coli or coli-like organisms may be present in fish inhabiting such localities. I have examined several varieties of fish caught in Aberdeen Bay, round the area where sewers discharge, and in many of these the colonies of the coli bacillus were present in enormous numbers in the media used; whereas in the case of fish known to be caught some distance from land the colonies were generally few in number.

Houston, working on guillemots and gulls, found that, whereas the intestinal contents of the former, in culture, yielded negative results as regards the bacillus coli, bacillus enteritidis sporogenes, and strepti-cocci, the intestinal contents of the latter contained bacillus coli in enormous numbers, and also, although not so numerous, bacillus enteritidis sporogenes and strepti-cocci—the intestinal organisms closely associated with the coli bacillus. He ascribes this result to the different habits of feeding; guillemots are clean feeders, whereas gulls feed on all sorts of filth.

In this respect the study of the life history of the mussel is very interesting and instructive, for its varying life conditions appear to have a considerable influence in determining its wholesomeness or unwholesomeness. Some investigations were made by Virchow and Schmidtmann and by Wolff and König. The former found that when poisonous mussels were left in pure sea water they became harmless in less than one month. The latter showed that if non-poisonous mussels were placed near a sewage outlet, or even in the water of a harbour, they became poisonous in about two weeks. If now these mussels are transferred into the neighbourhood of a sluice, where the water is frequently changed, they very soon again become harmless.

These considerations raise some very important questions. It is possible that the bacillus coli may not be a natural nor a necessary inhabitant of the intestinal canal in certain lower animals, but may have become so by finding a temporary lodgment through the exigencies of living and feeding, and then by laying aside the saphrophytic and taking on the parasitic habit; while, as already shown, the number of coli present in a fish depends largely on topographical considerations influencing the type of feeding.

Such questions as these, and the now recognised possibility of birds, fish, etc., as important bacillus coli carriers, infecting one another, polluting oyster-beds, rivers, and streams, foodstuffs and water supplies; as also the different views held whether all kinds of excremental pollution is potentially dangerous to health, or whether it is only danger-

ous in degree, as it is dejecta from a human source ; and finally, the very great influence which the consideration of such matters is destined to exercise on many public health questions—*e.g.*, Is the presence of bacillus coli synonymous with sewage pollution ?—I shall not discuss here, as it is not within the scope of this paper. But I may add, in conclusion, that, since for the present the bacillus coli is accepted as the best indicator of excremental pollution, while at the same time bacteriology fails to distinguish between coli bacillus from human sources and those derived from the lower animals, and since from the public health point of view the one or the other has quite a different significance, the bacteriologist in future, having due regard to all local conditions, will require to interpret his results more in a relative and less in an absolute sense. For it is only by a judicious weighing of the bacteriological results with all the topographical data that an approximately reasonable and correct estimate can be formed of the potential danger to health regarding many of the important questions which have so frequently been considered by public health authorities.

18. Summary regarding Detection of Decomposition in Fish.

After discussing the various factors concerned in the decomposition of fish and the various criteria ordinarily applied in its detection, the important question still remains—how far these criteria are applicable and reliable in the hands of those whose daily duties are the examination of fish. Although it may be conceded at once that it is probably unsafe to consider any one of these criteria as individually absolutely reliable, yet, in reviewing the whole question, I am inclined to consider the following five tests as fairly reliable in giving comparatively trustworthy evidence as regards the condition of a fish :—

1. The presence or absence of rigor mortis.
2. The presence, degree of development of, or absence of, reddish discoloration on the ventral aspect of the backbone.
3. The smell.
4. The manner in which the flesh separates from the backbone.
5. The appearance of the abdominal walls.

I. So long as a fish is in the condition of rigor mortis it is a guarantee that it is perfectly fresh, since decomposition can only set in as rigor passes off; the ordinary tests for which, already enumerated, are—degree of rigidity on handling and balancing, flesh firm and elastic and does not pit readily on pressure. The chemical changes in the muscle are also important—acid during rigor, becoming alkaline as rigor passes off, and finally distinctly alkaline when decomposition has set in—both to litmus paper. But since, under the most favourable conditions under which fish are treated, rigor mortis is of short duration, its absence is no guarantee that fish are not sufficiently fresh and not fit for human food.

II. At this stage the presence or absence of reddish discoloration on the ventral aspect is invaluable, and should always be looked for. If it is present, we know that the fish are certainly quite fresh. The time will probably be about 48 to 60 hours after capture or after landing. But even at this stage the fish may not be such as should be condemned as unfit for human food or for curing purposes. Yet, when one sees this discoloration fully developed, it should make one suspicious and more cautious as regards the condition and cause one to examine them more

critically by further tests. Also, it has to be kept in mind that, to pervent this discoloration, an attempt is sometimes made to remove the large caudal vein along with the gut.

III. The sense of smell in the examination of fish is invaluable in spite of the difficulties already discussed. I have attempted to describe smell in terms of fresh, fishy, and sea-weedy for one large class of fish; as fresh, fishy, and oily in another large class of fish, and to contrast these with such terms in every-day use as tainted, stale, and putrid. Although one at the same time recognises the different and relative degrees of development of the sense of smell, and consequently the difficulty in getting unanimity in different individuals of what constitutes these different terms, yet the test of smell is both a time-honoured and a reliable standard. One will usually find that, as the red discoloration is appearing, the smell is passing from fresh to tainted and stale. The fish is now on the borderland, and one smells critically for an approaching putrid odour, when the fish should be at once condemned.

IV. When a fish is fresh it requires considerable pressure to strip the flesh from the backbone, and in doing so many tags of flesh are left adhering to the bone. As decomposition, and consequently softening, progresses, the flesh gradually strips off cleaner. Hence, when one finds that the flesh comes away readily and comparatively cleanly from the bone, or that the bone can be stripped readily and cleanly from the flesh, one may feel convinced that the fish are certainly not fresh, that decomposition, if not well advanced, has certainly commenced, and by this and other tests proposed one will feel warranted in condemning such fish.

V. In examining the interior of the abdominal cavity one notes the condition of the kidney, situated anteriorly and ventral to the backbone. It is a very diffuse, vascular, and friable organ, and very rapidly breaks down, passing through different shades of colour, to form a reddish-brown debris in from 24 to 48 hours, while the fish may be still quite fresh. But more important is the condition of the abdominal walls. If they are firm and elastic, with absence of discoloration and presence of fresh, characteristic smell, one may feel assured that the fish are fresh. On the other hand, if the walls are soft and pulpy, with apple-jelly-like appearance and presence of discoloration, with tainted odour, while the fish is becoming alkaline to litmus paper, then such fish require very careful consideration, and it will generally be found that, with other confirmatory evidence present, such fish should be condemned.

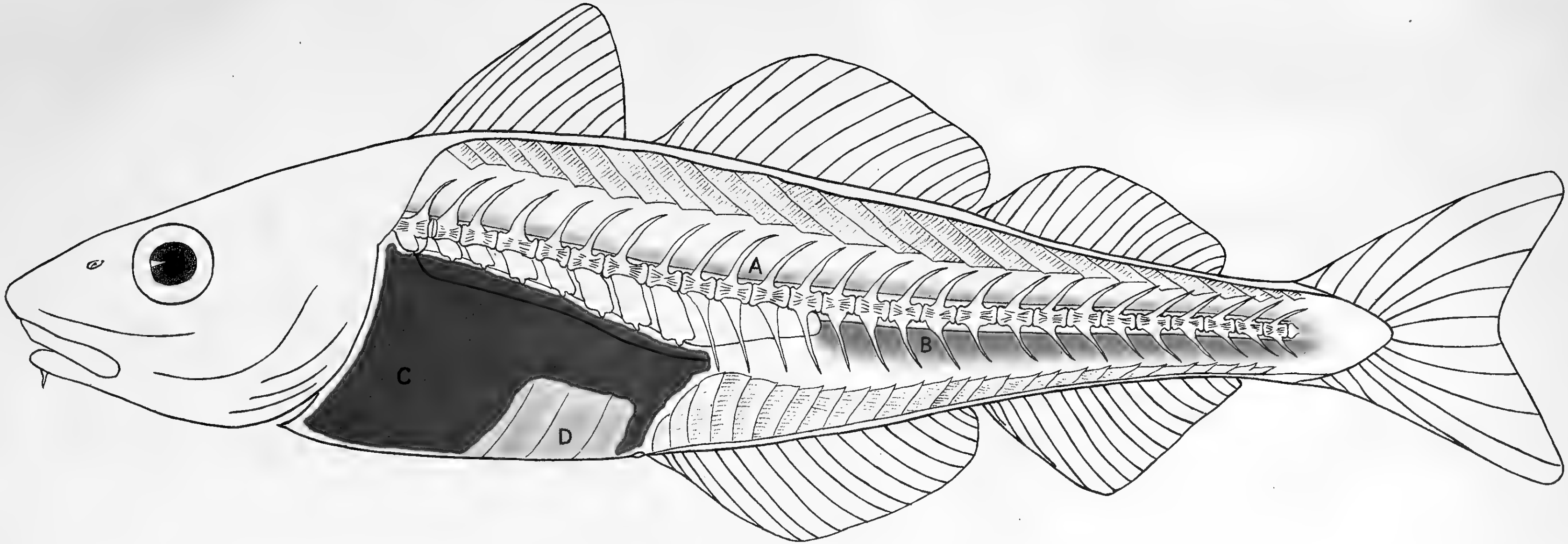
Other common tests which should never be omitted are—

VI. *The Appearance of the Gills.*—The gills of most fish are red in colour, with certain specific tints. These tints disappear in about from 24 to 36 hours, and the gills become grey and slimy by the third to fourth day. So long as the gills retain their natural colour there is a strong presumption that the fish are fresh. But one has to keep in view that the gills often retain their characteristic colour with little change—especially if washed daily in tap or, still more, sea water—even when the flesh is becoming putrid; that on the whole the gills of trawled fish are often paler at the time of capture than line fish, and more so the longer they have been in the trawl net; also that one finds degrees of paleness even among perfectly fresh fish.

VII. *The Appearance of the Eye.*—The appearance of the eye should always be noted. The full and prominent eye, with jet-black pupil and transparent cornea, of the fresh fish presents a very decided contrast to the grey and shrunken eye of a fish four or five days after capture.

VIII. *The Appearance of the Scales.*—One notes the absence or presence of characteristic sheen, the firmness or looseness of the scales, and if they

PLATE I



rub off readily. If the scales present a patchy appearance it indicates that the fish are probably trawled or have been roughly handled.

IX. *The General Appearance.*—In looking at a fish, the appearance it presents often indicates whether it is a trawled or line fish. In the former the body region generally shows a battered and limp appearance, with often considerable extravasation of blood in the head region.

From the above considerations, I venture to state that when—

1. Rigor mortis has passed off,
2. Reddish discoloration, fully developed as described, and as shown on the figure in Plate I.,
3. Smell becoming tainted, passing to putrid,
4. Flesh strips off readily and cleanly from backbone,
5. Abdominal walls becoming soft and pulpy, with commencing apple-jelly-like appearance and with commencing discoloration and tainted odour,
6. Gills lost characteristic tint, becoming grey and slimy,
7. Eyes grey and shrunken,

such fish should unhesitatingly be condemned.

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19. EXPLANATION OF PLATE I.

Diagram of dissection of Haddock, about three days after capture.

A—Slight reddish discoloration due to diffusion of blood-pigment from small blood vessels on dorsal aspect of vertebral column.

B—Deeper reddish discoloration due to diffusion of blood-pigment from caudal blood vessels on ventral side of vertebral column.

C—Peritoneum.

D—Peritoneum removed and abdominal walls breaking down, showing pale apple-jelly colour—"Jelly Lugs."

II.—ON SEA-FISH HATCHING.

The Lochfyne Experiments with Plaice. By Dr. T. Wemyss Fulton, Scientific Superintendent.

(Plate II.)

TABLE OF CONTENTS.

1. Introduction.

It is now a considerable number of years since the artificial propagation of sea fishes was introduced with the object of increasing the abundance of certain species on the fishing grounds. It was first begun by the United States Fish Commission in 1878, when several millions of cod were hatched and turned into the sea, and it has since been regularly prosecuted in America on an increasingly large scale. Later, in 1884, the well-known Norwegian cod hatchery was established at Flodevigen, near Arendal, and other hatcheries for marine food fishes have been instituted in America, New South Wales, New Zealand, England, and Scotland, the latest being a hatchery for plaice at Drontheim, Norway.

It is in the United States that the artificial culture of the food fishes has been conducted on the greatest scale. According to the latest report of the Commissioner of Fisheries,* the amount voted by Congress for the propagation and distribution of fish and eggs in the fiscal year, including the maintenance of stations, was 275,000 dollars, while other 179,180 dollars were provided for the salaries of employees directly concerned in fish culture, the total appropriation being 454,180 dollars, or about £94,600. The piscicultural work of the Bureau of Fisheries is in the main concerned with fresh-water forms, and there is no means of showing the amount expended on the propagation of marine fishes; but three permanent hatcheries (at Gloucester, Mass.; Woods Hole, Mass.; and Boothbay Harbour, Me.) and several temporary hatcheries are devoted to this branch of the piscicultural work. In the year named the output of fry from these hatcheries was as follows:—Cod, 235,422,000; winter flounder, 178,625,000; pollack, 86,299,000; haddock, 2,499,000; tautog (a Labrid, *Tautoga onitis*), 450,000; lobster, 167,909,000. These figures sufficiently show the extent of the work in the United States.

The artificial propagation of food fishes is also carried on very extensively in Canada, the amount of the appropriation for it in the fiscal year ending 31st March, 1907, being 158,000 dollars, or nearly £33,000.† Most attention is devoted to fresh-water forms, but five of the 34

* *Report of the Commissioner of Fisheries to the Secretary of Commerce and Labor for the Fiscal Year ended June 30, 1907.*

† *Fortieth Annual Report of the Department of Marine and Fisheries, 1907.*

hatcheries which were in operation were concerned with lobster culture, the output of lobster fry amounting to 501,000,000; the hatching of marine food fishes appears not to have been undertaken.

At the Norwegian hatchery at Flödevig, operations are practically confined to the cod, of which about 3,500,000,000 fry have been hatched and "planted" in adjacent fjords, the largest output in one year being 412,000,000. The annual expenditure, which is partly met by contributions from the State and partly by grants from the local Fishery Society, amounts to about £600 per annum. In England there are two hatcheries for sea fishes, plaice, and flounders, both being under the direction of Professor W. A. Herdman; one is situated at Piel and the other at Port Erin in the Isle of Man.*

2. The Sea-Fish Hatchery of the Fishery Board.

Since 1894 a hatchery for sea fish has been part of the scientific establishment of the Fishery Board, being worked in conjunction with the Marine Laboratory for fishery researches. From the year named until 1900 the hatchery was located at Dunbar, since when it has been located at the Bay of Nigg, Aberdeen. A description of the buildings, apparatus, and the methods employed has been given in previous reports of the Board,† and it will suffice to say here that the adult fishes are obtained from local trawlers; that they are retained all the year round in a large tidal pond, where they spawn naturally at the proper season, the eggs being collected from the water of the pond and transferred to the hatching apparatus in the hatching-house; and that the fry are liberated in the sea on the coast of Aberdeenshire. The methods and apparatus employed are the same as those used at the Norwegian cod hatchery, which was taken as the model for the Scottish establishment. Several of the food fishes have been dealt with, but attention has been concentrated from the first on the plaice, a fish which, as many recent researches have shown, appears to be declining very considerably on the fishing grounds.‡ The following is a statement of the number of eggs of the plaice collected and of the output of plaice fry, in each year since the work was begun:—

Year.	Eggs Collected.	Fry Liberated.
1894	27,250,000	26,060,000
1895	44,035,000	38,613,000
1896	14,970,000	11,350,000
1897	30,960,000	24,370,000
1898	21,500,000	19,200,000
1899	18,700,000	16,470,000
1900	43,290,000	31,305,000
1901	65,377,000	51,800,000
1902	72,410,000	55,700,000
1903	65,940,000	53,600,000
1904	39,600,000	34,780,000
1905	40,110,000	24,500,000
1906	7,486,000	4,406,000
1907	1,627,000	1,282,000

* *Annual Reports of the Lancashire Sea Fisheries Laboratory; Annual Reports of the Liverpool Marine Biology Committee.*

† *Twelfth Ann. Rep., Part III.*, p. 196; *Twenty-fourth Ann. Rep., Part III.*, p. 108.

‡ Vide *Annual Report of the Board of Agriculture and Fisheries on the Sea Fisheries for the year 1906*, pp. 7, 10, &c.; *Report of the Board of Agriculture and Fisheries on the Research Work in relation to the Plaice Fisheries of the North Sea, 1908.*

The fluctuations in the numbers from one year to another were owing, as a rule, to the variation in the stock of the adult spawning fishes in the pond; the decline in the last two years was caused by the stock being very small, the usual method of obtaining supplies by the use of a trawler in the Moray Firth and Aberdeen Bay having been given up for reasons explained elsewhere.*

Besides plaice, other food fishes were dealt with in some years, the following numbers of the fry being liberated:—Cod, 4,010,000; turbot, 5,160,000; lemon dab, 5,725,000; haddock, whiting, &c., 2,000,000. In addition to fish, in some years considerable numbers of the larvæ of lobsters and of the edible crab were hatched and placed in the water along the Aberdeenshire coast.

It has to be added that the expense of the hatching work is comparatively small, since the hatchery is operated in conjunction with the Laboratory, the additional outlay for coals, food for the fishes, &c., being estimated at between £60 and £100 per annum.

3. The Principles of Sea-Fish Hatching.

The theoretical objections which are usually made against the artificial propagation of sea fishes for economic reasons are based upon consideration of the vast area of the sea, compared with lakes and rivers, and upon the great fecundity of most sea fishes, especially those which have pelagic eggs. But though the extent of the sea is vast, the parts frequented by the food fishes—the fishing grounds on which the fish are caught—are relatively small, and are usually confined to the neighbourhood of coasts, or to banks situated in propinquity to them. Moreover, though the range of wandering of the individuals of many species in relation to the part of the coast where they are born or bred is not well known, we do know that, with regard to plaice at all events, in the earlier years of their life the extent of wandering is, as a rule, small. Thus, in the extensive marking experiments carried on in the Firth of Forth and St. Andrews Bay by myself, and on the Northumberland coast by Professor Meek, approximately 90 per cent. of those which were recaptured were taken within a few miles of the locality at which they had been liberated, sometimes after an interval of two years or more. Such instances show that the natural range of individuals of certain species may be quite restricted on the whole, and they materially modify the application of the argument drawn from the vastness of the sea.

With regard to the great fecundity of sea fishes, it is to be observed that some of the arguments used by the opponents of artificial propagation show that the question is not thoroughly understood. Comparison is sometimes made between the number of *larval fishes* or "fry" turned out from the hatcheries and the number of *eggs* produced by the female fishes as if the two things were the same. Thus, if 100,000,000 cod larvæ are turned into the sea, it is assumed that this result would have been produced if a few score of cod had been left in the sea to propagate naturally, because owing to the fecundity of the cod a few scores of females would have spawned that quantity of eggs. By a similar process of reasoning, 100,000,000 larvæ of the plaice might be produced by about 330 female plaice (or, taking the males into account, by about double that number) spawning under natural conditions in the sea. Such estimations entirely omit to take into account the measure of protection afforded during the whole of embryonic development and

* *Twenty-fifth Ann. Rep.*, *Part III.*, p. 256.

during the greater part of larval life, the advantage of which is enormous. The fecundity is indeed, in a certain sense, a measure of the natural destruction that takes place in the individuals of a species. Since, on an average, two parents require to produce eventually only two reproductive adults in order to keep up the normal number of the species, it follows that the product of all the other eggs, except those which give rise to the two individuals in question, are destroyed at some period or other of their lives; from two or three million cod eggs only two reproductive individuals survive, on an average, to carry on the species and maintain its normal numbers.

It is well known that it is in the early stages that the greatest destruction occurs in nature, that is to say, in the embryonic or egg stage and in the larval stage. There is not sufficient information to enable one to apportion with exactness the relative destruction that takes place in the egg stage and in the larval stage, or in the later stages, but there are reasons which show that the natural loss of pelagic eggs must be very large, as in the case of the plaice, the cod, and most of the food fishes. The fecundity of fishes which have demersal eggs, lying on or attached to the bottom, is very much less than the fecundity of fishes which produce pelagic or floating eggs. Thus, the mean number of eggs among twelve species investigated in which the eggs are demersal was 24,700, whereas the mean number among twenty-three species with pelagic eggs was 2,388,000, or nearly 100 times greater. This enormous difference in the fecundity cannot, however, be taken as an exact measure of the greater natural destruction of pelagic eggs as compared with demersal eggs, for some other influences are in operation; but there is no doubt that a great part of the difference is to be explained in this way, and that large numbers of the pelagic eggs, at the mercy of the waves and currents, are stranded (as Sars noted with those of the cod at the Lofoten Islands) or otherwise destroyed.

It would be of value in this connection if a large body of accurate information existed to show the relative proportions of the eggs, larvæ and post-larvæ of the food-fishes existing under natural conditions in the sea. It does not appear that such complete information has been published, but there are many observations which clearly indicate that the number of larvæ within an area is much less than the number of eggs. In looking over the lists of the tow-net collections of pelagic eggs and larval and post-larval fishes made by the "Garland," and published in various reports of the Fishery Board, the great preponderance of the eggs is noteworthy; but the relationship cannot be expressed in figures, because exact numbers are not always given. In an extensive series of tow-net collections made by Mr. Knut Dahl* in certain Norwegian fjords in 1904 an accurate record was kept of the number of pelagic eggs and of the pelagic young fishes obtained, summarised as follows:—

* "Undersögelser over Nytten af Torskeudklækning i Östlandske Fjorde." *Aarsberetning vedkommende Norges Fiskerier for 1906*, pp. 93-97.

[TABLE.

Place.	No. of Collections.	Pelagic Eggs.			Pelagic Young.						
		Total.	Over 1 mm.	Cod in last stage.	Cod.	Haddock.	Whiting.	Pollack.	Flounder.	Motella.	Total.
Söndeledfjord, 13th April-28th May	41	33,867	26,950	266	222	75	18	7	173	4	499
Risör & Skagerrack, 16th April-30th May	11	6,567	3,795	1	11	20	12	1	8	1	*54
Sandnesfjord, 22nd April-30th May	11	25,376	21,100	4	5	17	4	...	47	2	75
Total.	63	65,810	51,845	271	238	112	34	8	228	7	628

* Including one unknown cod species.

The total number of pelagic eggs was 65,810, and the total number of pelagic fry derived from pelagic eggs was 628, or in the proportion of 1 young fish to every 105 eggs. The eggs over 1 mm. in diameter, comprising those of cod, haddock, whiting, and pollack, numbered 51,845, and the young of the species named numbered 392, the ratio being 1 young fish to 133 eggs In another series of observations made in 1905 in the same localities, the total number of pelagic eggs collected was 54,751, and the number of young fishes derived from pelagic eggs was 1514, or in the ratio of 1 young fish to 36 eggs; but in this case young herring, which are derived from demersal eggs, are included along with young sprats—there were 31,848 sprat eggs collected and 348 young sprats and herring, the ratio being 1 young clupeoid to 91 sprat eggs. If the results of the two years' observations are combined, we have 120,561 pelagic eggs and 2142 young pelagic fish derived from pelagic eggs (but inclusive of some young herring), the ratio being 1 young fish to 56 eggs.

In these experiments the tow-netting was limited to the upper layers of water, not deeper than 30 metres from the surface, owing to the depth at some of the stations not exceeding that; but Dahl points out that the relative distribution of the eggs and fry was absolutely the same, the larvæ, if anything, seeming to be more numerous than the eggs in the upper layers.† This conclusion is partly borne out by the following analysis I have made, showing the percentages of eggs and fry at the different depths:—

Depth, in Metres.	Pelagic Eggs.	Fry derived from Pelagic Eggs.
0	9·0	9·7
2	18·0	12·2
5	21·6	16·1
10	23·3	34·0
20	28·2	28·0

It shows that practically the same proportion in each case is above 20 metres.

† "The Problem of Sea-Fish Hatching," pp. 18, 20.

It is to be noted that the young fish referred to include post-larval forms as well as larvæ. Thus, in a table of measurements of the young cod, haddock, and whiting obtained, it is seen that among the cod 204 were over 5 mm. in length, and 557 were 5 mm. or less, the largest included being 28 mm. Of 222 young haddocks, 79 were 5 mm. or under, and 143 over that size, the largest being 38 mm. Of 142 whiting, 18 were 5 mm. or under, and 124 above 5 mm., the largest being 11 cm. It would therefore appear that the proportion of larvæ derived from pelagic eggs to the number of pelagic eggs must be considerably less than above stated.

In Lochfyne, Williamson carried on a series of tow-nettings from 17th January to 9th August, and determined the eggs and young fishes.* The collections were made at various depths down to 15 fathoms, or to about the same depth as in Dahl's observations. The total number of eggs of the Gadidæ obtained was 17,675, and the number of gadoid fishes 103, the ratio being 171·6 eggs to each fish; the number of eggs of the cod was estimated at 6618, and the number of young cod was 86, the ratio being 77 eggs to each fish. The number of eggs of flat-fishes was 9259, and the number of young flat-fishes was 43, the ratio being 215 eggs to 1 fish; the number of plaice eggs procured was 538, and the number of young plaice was 8, the ratio being 67 eggs to 1 fish. The total number of eggs of the gadoids and flat-fishes was 26,934, and the total number of larval and early post-larval fishes of these groups was 146, the ratio being 184·5 eggs to 1 fish.

As previously indicated, observations are not yet complete enough to allow of an exact comparison being made between the numbers of pelagic eggs and the larval fishes derived from them, as they naturally exist in the sea, but they show at all events that the biologic value of a larval fish is much greater than that of a pelagic egg, and it is probably not overstating the case to say that it is twenty times greater. If that is so, then the 100,000,000 larvæ of the plaice referred to previously would represent the sexual product not of about 600 female and male fish but of about 12,000 living under natural conditions.

The natural destruction that goes on among the eggs from physical causes and from enemies is continued in the larval stage, and no doubt mainly in the early part of that stage, when the young fish is entirely dependent for its nourishment on the supply of yolk it possesses and is comparatively inert. Later, when it begins to feed and gain in vigour and activity, it is presumably better able to escape its enemies and has a better chance of surviving.

With regard to the plaice, we have a considerable amount of information relating to the value of protection in the early stages. The duration of embryonic development within the egg depends upon the temperature of the water; in February it occupies about 24 days, in March about 22 days, in April 19 or 20 days. The larval stage, before the yolk is absorbed, endures for seven or eight days, and the duration of the post-larval stage, until the plaice settles on the bottom as a little flat-fish is from 29 to 40 days, the mean being 34 or 35 days.† As the young fish are kept in the hatchery until near the close of the larval stage, protection is thus afforded for about half the period between the spawning of the egg and the completion of transformation, when the young fish lives on the bottom in comparative security; and there is little doubt that it is in the first half of pelagic life, as egg and as larva, that the greatest destruction occurs.

* *Seventeenth Ann. Rep., Fishery Board, Part III.*, p. 79

† *Fifteenth Ann. Rep., Part III.*, p. 175.

4. Proofs of Results.

Although such theoretical considerations as are above stated have sufficed for the continuance of the artificial propagation of sea fishes, and on an increasing scale, it would clearly be of advantage if evidence of a definite kind were forthcoming to prove the results of the work. It is not doubted that in areas of water under more or less complete control, within which the effects can be ascertained with comparative ease, piscicultural operations may be beneficial and profitable. The great extension of carp culture in ponds, as in Germany, is an illustration of what may be accomplished in such circumstances. Oyster culture, where the conditions can be to a large extent controlled and the results determined, is another illustration relating to the sea. But where the areas are very large, as in the great lakes of North America, or where rivers are concerned, as in salmon culture, the conditions cannot be controlled in this way, nor can the results be easily ascertained. In such cases it is extremely difficult to separate the results due to natural causes, or due to the action of other kinds of artificial interference, as fishery regulations, from those caused by the liberation of large numbers of artificially-hatched fry; usually, indeed, the particulars which are necessary to come to a definite conclusion are awanting. Notwithstanding the absence of definite statistical evidence of this kind as to the amount of benefit derived from piscicultural operations, it is to be noted that in almost all countries the number of fish hatcheries and the money expended on fish hatching are increasing year by year, which may at least be taken as a proof that those responsible for the policy and for the expenditure are satisfied that the results are beneficial. The Fish Commissioner of the United States, in speaking of the general results of the piscicultural operations, makes the following remarks:—"Encouraging results of the efforts of the Government to maintain the fish supply by artificial means appear in reports from fishermen and fish culturists in all parts of the country. Although it is difficult to establish definitely the extent to which the hatcheries have affected the condition of the commercial fisheries of the coastal waters and the Great Lakes, the renewed productiveness of old and abandoned fishing grounds and the abundance of fish on entirely new areas are strongly indicative. Unusual numbers of cod are reported all along the coast, and surprising catches have been made on inshore grounds. In spite of the growing scarcity of adult lobsters and the ruthless destruction of young and eggs during the last ten years, fishermen on the New England coast have been finding in their traps many more young lobsters than formerly; flat-fish are much more numerous, especially small flat-fish, in the shallow waters along shore; and exceptional catches of white-fish were made this year in Lake Ontario and Lake Erie, which fishing firms operating there attribute wholly to the planting of artificially-hatched fry."* In Canada, Professor Prince, the Commissioner and General Inspector of Fisheries for the Dominion, notes in his report on the fish-breeding operations in 1907 the existence of the same views as to the benefit of the work. "Public opinion," he says, "is indeed favourable in the highest degree to the expansion of artificial fish-breeding in its various branches, and the federal government has not been slow to recognise the desirability of extending hatchery operations."† Another example of the same policy—the recommendation of fish culture as a means of increasing the supply, without exact statistical knowledge

* *Report of the Commissioner of Fisheries for the Fiscal Year ended June 30, 1906*, p. 5.

† *Fortieth Annual Report of the Department of Marine and Fisheries, 1907*, p. 232.

of the benefit derived—is to be found in the Report of the Irish Inland Fisheries Commission. This Commission, three of whose members were scientific men (Mr. Wm. Spotswood Green, the head of the Irish Fisheries Department; Professor W. C. M'Intosh, of St. Andrews; and Professor D. J. Cunningham), referring to the maintenance of hatcheries by the net owners in their own interest, and recognising that this "furnished the best evidence of the belief of those who possess practical acquaintance with fishery matters in the efficacy of artificial propagation," strongly recommended that a central hatchery should be established in each province of Ireland, which should be erected, fitted up, and maintained out of funds under the control of the Fishery Authority, and be directly under the supervision of the Department; and they stated that the foreign authorities to whom they applied for their opinion as to whether artificial breeding was beneficial all replied in the affirmative." *

In this category of opinion or evidence must be placed the statements made from time to time by fishermen as to the influence of fish hatching on the abundance of the fishes on the grounds frequented by them. In the United States and in Norway the fishermen in the neighbourhood where the fry have been liberated have not unfrequently stated their opinion that the work was beneficial in increasing the supply of fishes, and in years of abundance they commonly attribute this abundance to the operation of the hatcheries. At certain parts of the coast of Aberdeenshire the line fishermen, who annually petition for supplies of plaice fry from the Hatchery at the Bay of Nigg, have also expressed the opinion that the liberation of the fry along the coast has increased the number of plaice in the inshore waters. There is nothing improbable in these statements. The fishermen may be quite right in tracing an increase to the effect of the fish-hatching work; but they may be wrong; and when the numerous causes which may operate in producing such fluctuations in abundance are borne in mind, it is clear that evidence of this kind must be very extensive and particular before it can be accepted as a proof.

Another means suggested by which the effect of the artificial propagation of sea fishes might be ascertained is by a comparative study of the ordinary statistics of the fish landed. Unfortunately, statistics of this kind are not at present suited for the purpose, since no particulars are afforded of the extent of fishing operations or the place where the fish are caught, and they cannot even be used to indicate the measure of general fluctuation, that is to say, whether a particular species is increasing, decreasing, or stationary in numbers on any fishing ground, from any cause whatever, natural or artificial. Thus it would be impossible to make use of these statistics to determine the fluctuations in the abundance of plaice from year to year along the coasts of Aberdeenshire and Kincardineshire: the fish landed may be caught in quite distant waters, even at Iceland, and there is nothing to show the extent or amount of the fishing operations by which they are caught in the different years. For these reasons, among others, it is evident that the attempt which has been made to judge of the efficacy of cod-hatching in the fjords in the south-east of Norway by a study of the figures showing merely the total catch of cod for the whole of that country must be fallacious.† Moreover, the number of cod taken and the fluctuations from year to year are enormous —the total has varied from under 40,000,000 to over 70,000,000 fish—

* *Irish Inland Fisheries Commission, Report of the Commissioners, 1901,* p. 13; *Appendix, Part II.*, p. 20 *et seq.* The countries were Germany, the Netherlands, United States, State of California, Canada, British Columbia, Norway.

† *Tenth, Eleventh, and Twelfth Annual Reports of the Inspectors of the Sea Fisheries of England and Wales,* pp. 23, 28, 33.

and while the hatchery is situated on the south coast and the fry are "planted" in the neighbourhood, the great bulk of the cod are caught on the west and north coasts, about 70 per cent. or more being taken within the Arctic circle, from 800 to 1200 miles from the locality where the hatching operations go on, and thus much farther from that locality than are the eastern coasts of Great Britain. Conclusions formed in this way are of no value, and the problem of the amount of benefit from sea-fish hatching is not likely to be solved by means of the general fishery statistics of any country. There are, however, some experimental proofs of a special kind, referred to below.

The results of the piscicultural operations might be tested in three ways—(1) by the introduction of a fish not indigenous to the region; (2) by a system of special statistics of the fish caught in the region over a series of years when no fry were added to the waters and over another series of years when fry were liberated; (3) by special investigations to determine the abundance of the young fish in years when fry were added and in years when they were not added. A most impressive body of evidence of the kind first named has been afforded by the work in America with the shad, as shown in various Reports of the Fish Commission.

5. The Acclimatisation of Shad in the Pacific.

The shad (*Clupea sapidissima*) is an anadromous fish belonging to the herring family which lives for the most part in the sea but resorts to estuaries and rivers to spawn. It did not exist in the Pacific, but in 1871 a consignment of 10,000 fry, about eight days old, obtained from the Hudson River on the Atlantic coast, were put in the Sacramento River, California. In 1873 other 35,000 fry were added; in 1876, 99,000; in 1877, 110,000; in 1878, 150,000; and in 1880, 215,000—the total being 619,000 shad fry. From these small colonies great results have come. An adult shad is said to have been taken in 1873, and 16 were obtained in 1874 and 1875; in 1876 and 1877 they had become quite common in the Sacramento River, and some were found along the coast over an extent of 400 miles. In the spring of 1879 several thousand mature shad were sold in the market at San Francisco, and in 1886 the Californian Fish Commission estimated that a million good-sized shad were taken in the waters of the State; in 1895 it was reported that the shad was one of the most abundant fishes of California, the quantity taken being enormous, and the prices less than in any other State. Its extension along the coast was remarkable. In 1882 it had reached Puget Sound, and in 1895 its distribution extended from Los Angelos County, California, to Wrangell Island, Alaska, the range covering about 2700 miles of coast line, including the major indentations; but from the standpoint of commercial importance its distribution was from Monterey Bay to Puget Sound. In recent years the fish has become so abundant that the price has gone down enormously, being often less than a cent. per pound, and of the tons taken in the salmon-seines nearly all are now thrown back into the water or used as fertiliser. In 1899 the quantity marketed in the Pacific States was 1,254,800 lbs., valued at 15,898 dollars, and the aggregate value since the introduction of the fish has been over 300,000 dollars.

In this case there can be no doubt of the benefit derived from the artificial propagation of the fish, for since it did not previously exist in the waters of the Pacific the effect could be clearly traced to the liberation of the fry, a matter which is by no means easy when, as is usually the case, the fish is indigenous, and fry added merely go to increase the quantity naturally present.

6. Special Statistics.

As already mentioned, there are no statistics available which furnish the particulars necessary to prove the benefit from sea-fish hatching. The nearest approach to them perhaps are the statistics showing the catch of cod and other fishes from the Christianiafjord over some 36 years, which have frequently been referred to in connection with fish-hatching. These statistics have never yet been published in a collected form, and I am indebted to Mr. Knut Dahl for the detailed statement of them, which that gentleman has kindly extracted from the various reports in which they are contained, and which is subjoined here. They refer to two divisions of Christianiafjord, the part within and the part without Dröbak, and to the number of cod, whiting, and mackerel, and the weight of flat-fish, in pounds, taken from these two areas and sold at the market of Christiania; the figures thus relate only to the sale in the fish-market, and do not show the unknown quantity caught in the fjord and sold elsewhere in the district. Probably a much more serious defect in these statistics from the present point of view is that there is no information showing the amount of fishing expended in the various years in relation to the quantity of fish sold. It may well be that in a year when the quantity of fish was large the quantity of fishing gear or the intensity of fishing was also great, and the opposite. It may also be noted that the term "flat-fish" appears to include several species, with the exception of halibut.

The interest of the figures in relation to the question of fish-hatching lies in the fact that for a number of years cod fry from the hatchery at Flödevig were placed in the fjord, and that since then the quantity or number of cod taken from the fjord and sold at the market at Christiania has steadily increased. Without particulars as to the relation between the extent of fishing operations and the quantities caught in each year, it would not be possible to establish the precise connection between the liberation of fry, and the increase in the quantity of cod, but inasmuch as the area of the fjord within Dröbak is not very great, and it may be supposed that the amount of fishing has a rough relation to the abundance of fish in any year, a steady increase of the kind might offer presumptive evidence that the liberation of the fry was beneficial. Cod fry began to be added in 1892, usually from ten or fifteen to twenty millions annually, and it will be seen from the table that in each year since the number of cod taken from this part of the fjord and sold at Christiania has greatly increased. Taking the average of each successive six years in the period of 36 years we have the following:—

	Average No. of Cod.		Average No. of Cod.
1872–77....	88,778	1890–95....	52,061
1878–83....	58,075	1896–1901..	83,852
1884–89....	62,256	1902–07....	102,398

The statistics, however, include particulars as to other fishes besides the cod, namely, whiting, mackerel, and "flat-fishes." The latter need not be further referred to since several species are included, but those referring to whiting are important, and they show that the numbers of this fish have increased in even greater ratio than the numbers of the cod. The averages for the six-year periods are as follows:—

	Average No. of Whiting.		Average No. of Whiting.
1872–77....	78,193	1890–95....	63,148
1878–83....	26,123	1896–1901..	139,113
1884–89....	47,147	1902–07....	180,067

The figures for each of the years, as given in the table below, show that whiting have gone on increasing, practically without a break since 1889, and whereas the number in 1892 was 56,240, it was 227,400 in 1907, while cod in 1892 was 44,013, and in 1907 the number was 114,013.

TABLE showing the Number of Cod, Whiting, and Mackerel, and the Quantity of Flat-fish, in pounds, from the Christianiafjord, inside and outside Dröbak, brought to the Market at Christiania in the years 1872–1907.

YEAR.	COD.		WHITING.		MACKEREL.		FLAT-FISH.	
	Inside.	Outside.	Inside.	Outside.	Inside.	Outside.	Inside.	Outside.
1872	91,836	150,056	198,860	76,340	23,002	217,451	16,710	2,796
1873	62,263	96,120	18,820	160	34,515	243,466	13,728	684
1874	72,039	103,048	51,540	0	548,217	890,400	14,532	10,968
1875	181,181	163,016	86,840	14,000	242,220	1,006,434	4,470	8,566
*1876	61,448	197,719	44,880	1,800	275,543	1,364,392	1,248	6
1877	63,904	109,272	68,220	5,640	43,393	194,108	3,024	9,132
1878	89,746	100,923	41,280	44,680	1,771,924	343,203	12,180	9,240
1879	69,368	137,295	47,260	13,800	161,297	343,465	8,772	10,812
1880	29,531	109,941	18,720	30,980	165,357	225,084	6,924	660
1881	35,400	97,854	14,800	52,360	80,487	297,381	4,012	4,200
1882	35,712	110,594	12,220	47,820	43,227	157,071	5,522	2,406
1883	88,694	140,966	22,460	71,620	85,154	375,181	1,786	7,640
1884	87,548	196,982	28,560	32,240	58,281	534,997	2,708	5,108
1885	110,868	172,469	93,800	76,080	115,317	347,804	3,344	40,856
1886	60,947	115,642	41,140	46,640	9,786	366,723	6,850	6,564
1887	34,561	78,202	25,880	37,820	80,585	495,936	1,824	5,224
1888	37,176	103,098	64,480	114,560	3,654	402,838	4,812	12,640
1889	42,436	108,696	29,020	98,140	15,942	241,253	3,750	9,340
1890	45,376	100,389	40,590	86,140	126,335	252,589	1,012	4,054
1891	41,443	91,742	50,480	104,640	8,042	239,726	1,060	3,528
1892	44,013	116,429	56,240	135,480	27,772	266,720	756	952
1893	50,322	123,057	66,140	142,360	33,311	225,780	0	3,080
1894	65,219	181,124	86,720	183,380	84,696	329,614	2,782	10,156
1895	65,996	191,285	78,720	176,060	65,996	278,855	0	2,564
1896	70,414	227,976	106,500	278,360	59,632	228,848	724	5,306
1897	70,868	203,929	121,380	411,700	52,263	290,580	1,314	3,986
1898	81,337	213,013	143,880	494,640	106,746	548,157	4,430	8,934
1899	78,760	218,295	159,580	880,620	200,819	493,574	1,340	4,516
1900	†101,350	‡...	160,420	‡...	86,664	‡...	2,768	‡...
1901	100,382	231,785	142,920	988,920	183,783	817,182	908	6,796
1902	95,592	313,625	146,140	969,340	181,520	904,331	420	5,016
1903	92,429	346,297	141,140	876,700	140,493	773,180	1,400	3,106
1904	95,841	388,894	138,160	1,023,960	389,020	821,965	2,198	13,074
1905	102,984	401,850	187,860	1,004,000	395,744	1,040,060	4,454	12,922
1906	113,530	466,080	239,700	1,157,180	502,371	1,329,720	6,608	10,168
1907	114,013	436,373	227,400	745,860	162,311	1,365,560	7,564	32,844

* Records for May, 1876, not included.
† From 1900 the figures include cod sold by various dealers.
‡ Not available.

The mackerel is a pelagic fish, and therefore in a different category, but the figures show that it also has increased in a remarkable way. The averages for the periods are :—

	Average No. of Mackerel.		Average No. of Mackerel.
1872–77....	194,482	1890–95....	57,692
1878–83....	384,574	1896–1901..	114,981
1884–89....	47,261	1902–07....	295,243

The whiting is to a considerable extent a competitor of the cod, and no fry of whiting were placed in the fjord, nor fry of mackerel, and the in-

crease of these species was not in any way due to artificial propagation. The conclusion, therefore, is that the increase in recent years in the numbers of these fishes brought to the market at Christiania has been brought about by the action of a general cause or causes, whether natural or economic, as increase in fishing. It does not of course follow that no benefit as regards cod accrued from the liberation of cod fry, but any benefit of the kind that may have been conferred cannot be separated from the results due to the operation of the general cause, and the proof therefore fails.

7. Special Investigations.

Two special investigations have been made to determine the effect of the liberation of larval fishes on the abundance of the young of the same species in the locality. One was made in Norway with reference to the cod, and the other in Scotland with regard to the plaice. The Norwegian investigation was carried on jointly by Mr. Dannevig, the Director of the Hatchery at Flödevig, and by Mr. Knut Dahl, of the Fishery Department. Certain fjords were selected in which the approximate abundance of young cod of the year was ascertained by hauls with a seine, at the same places and dates, both before and after fry of the cod from the hatchery were introduced into the fjords in question.* The results are shown as follows :—

	Söndeledfjord.			Hellefjord.		
	Cod Larvæ Liberated.	Cod Fry of Year taken.	Average per haul.	Cod Larvæ Liberated.	Cod Fry of Year taken.	Average per haul.
1903...............	None.	426	4·8	None.	36	1·9
1904...............	20,000,000	1,523	15·1	None.	133	6·5
1905...............	28,000,000	1,133	11·5	8–9,000,000	143	7·5

These hauls of the seine were taken in each year at closely-corresponding dates in September and October, but other hauls were also made in 1904 and 1905 in each fjord in July-August, with the following results :—In Söndeledfjord the average number of cod fry of the year per haul was 33·7 in 1904 and 11·5 in 1905; in Hellefjord the average was 10·9 in 1904 and 1·5 in 1905. Since fry were put in in both years in Söndeledfjord, the only point to be noted is the difference in the average in the two years, but in Hellefjord no fry were put in in 1904, whereas about eight or nine millions were added in 1905, when the average was low. The two investigators, unfortunately, do not agree as to the interpretation of the results of their investigations. Dannevig very naturally comes to the conclusion that the increase in the number of cod fry in the years in which cod larvæ were added in the spring was due to the addition of these to the fjord, and he gives the following summary of the results, including the numbers of other young gadoids taken :—

* *Aarsberetning vedkommende Norges Fiskerier for 1906, 1ste Hefte:* A summarised account by Mr. Dannevig and by Mr. Dahl of their investigations is given in the *Report on the Lancashire Sea Fisheries Laboratory for 1906*, pp. 104, 109.

1. *Before Planting of Fry.*

	Cod.	Whiting.	Pollack and Saithe.
Söndeledfjord, 1903...............	426	1,309	137
Hellefjord, 1903+1904÷2......	85	259	23
	511	1,568	160

2. *After Planting of Fry.*

	Cod.	Whiting.	ollack and Saithe.
Söndeledfjord, 1904+1905÷2...	1,328	1,150	160
Hellefjord, 1905	143	180	3
	1,471	1,330	163

While the numbers of young whiting decreased, the number of young cod greatly increased. On the other hand, Mr. Dahl, who also carried on other investigations in other fjords with a different net, and made observations on the hydrographical aspects of the problem, comes to the conclusion that the increase of young cod was caused not by the putting in of the larval cod but by general influences which affected other fjords as well. While the result of the joint experiments as they stand clearly shows that an increase in the numbers of young cod in the fjords followed the putting in of cod fry, and might well be due to that factor, the inference from the experiments that will probably be generally drawn is that expressed by Professor Herdman, that the observations are too few to lead to any sure conclusions. When one considers the natural fluctuations that occur, it is evident that the period over which the experiments extended was much too short. The normal natural abundance cannot be determined by observations covering only one or two years, nor would that period suffice to prove the results of artificial interference, whether such interference is caused by the addition of fry to the waters, as in these experiments, or by fishery regulations. For some certainty of result ten years would not be too long a period, and the value of the observations would be greater if two fjords were dealt with in such a way that in the years in which fry were added in the one they were not added in the other, provided that the fjords, while near enough to be under the same general hydrographic and other conditions, were not so near that the fry or young fish would be likely to pass from the one to the other.

8. The Experiments with Plaice in Lochfyne.

With the object previously explained, to determine if possible the effect of the liberation of large numbers of the fry of plaice within a restricted area of water, the experiment was begun in 1896 of transporting to Lochfyne a very considerable proportion of the larval fishes produced at the hatchery. This loch was in some respects well adapted for such an experiment. (Plate II.) It is about 36 nautical miles in length, and narrow, the width ranging from about $3\frac{1}{2}$ miles to under 1 mile. It is divided into two parts, the lower loch, about 14 miles in length and from $3\frac{1}{2}$ to $1\frac{3}{4}$ miles broad, and the upper loch, extending for about 22 miles above the narrows at Otter Spit to the head of the loch, and with a width of about $1\frac{1}{2}$ to $\frac{3}{4}$ miles. The water is on the whole deep.

In the upper loch the average depth is over 22 fathoms; in some places it reaches 75 fathoms. The average depth of the lower loch is greater, and in some parts the depth is over 80 fathoms. As a rule the water rapidly deepens from the shore, and the localities where there are stretches of sandy beach are few in number, that is to say, places suited for the life and growth of young plaice on the completion of their transformation and the commencement of their bottom habit.

The larvæ from the hatchery were transported by rail during the night, usually in large glass carboys, the water of which had been cooled to a suitable extent, ascertained by a number of experiments, and the fry were placed in the water in the upper loch early next morning, at a depth where a suitable salinity and temperature existed. The earlier consignments were carried in receptacles cooled by ice during transit, but the other method was found to be most satisfactory. All the fry were placed in the waters of the upper loch, and usually in the upper parts of it, and fry were put in in each year from 1896 to 1902, as detailed in the following Table:—

Year and Date.	No. of Fry Liberated.	Place where Fry Liberated.
1896.		
April 25	600,000	Off Inverae.
May 4	1,500,000	Between Furnace and Strachur.
„ 11	1,500,000	About 3 miles above Otter Spit.
„ 16	500,000	Lochgair.
	4,100,000	
1897.		
April 1	2,400,000	Between Lochgair and Minard Castle.
„ 10	3,200,000	Between Otter Spit and Lochgair.
„ 16	4,000,000	Off Strachur.
„ 23	3,300,000	Between Lochgair and Minard Castle.
„ 30	2,500,000	Off Lochgair.
May 5	2,100,000	Between Lochgair and Minard Castle.
„ 13	2,400,000	Off Penmore.
„ 24	1,270,000	Off Crarae.
	21,170,000	
1898.		
April 1	800,000	Off Inveraray, middle of Loch.
„ 12	1,400,000	„ „ „
„ 15	2,900,000	„ „ „
„ 22	2,700,000	„ „ „
„ 26	2,200,000	„ „ „
„ 29	3,400,000	Two miles above St. Catherine's
May 4	2,200,000	Off Inveraray, middle of Loch.
„ 10	1,300,000	„ „ „
„ 13	700,000	„ „ „
„ 17	900,000	„ „ „
„ 20	700,000	„ „ „
	19,200,000	

Year and Date.	No. of Fry Liberated.	Place where Fry Liberated.
1899.		
April 12	775,000	Off St. Catherine's.
„ 17	1,500,000	Under Strone Point.
„ 20	2,625,000	„ „ „
„ 25	800,000	Off Poll Point.
„ 28	1,400,000	„ „
May 1	1,400,000	Off Dunderave Castle.
„ 3	1,200,000	„ „
„ 5	1,100,000	Off Inveraray.
„ 8	1,200,000	Between Strone Point and St. Catherine's.
„ 10	900,000	Off Poll Point.
„ 12	1,200,000	„ „
„ 15	1,100,000	Off Strone Point.
„ 19	1,270,000	Off Inveraray.
	16,470,000	
1900.		
April 10	2,730,000	Off Strone Point.
„ 17	3,380,000	Between St. Catherine's and Dunderave Castle.
„ 24	4,290,000	Off Inveraray.
„ 28	4,160,000	Between Inveraray and St. Catherine's.
May 2	5,460,000	Off Poll Point, middle of Loch.
„ 5	5,600,000	„ „
„ 9	3,100,000	Off Strone Point.
„ 12	1,870,000	Between Strone Point and St. Catherine's.
	30,590,000	
1901.		
March 23	1,300,000	Off Inveraray, in middle of Loch.
„ 26	3,500,000	„ „ „
April 2	2,750,000	Off Strone Point.
„ 10	4,700,000	Off St. Catherine's.
„ 13	4,750,000	Off Strone Point (north side).
„ 22	10,150,000	Inveraray to Strone Point.
„ 27	8,000,000	Loch Shira and east of Strone Point.
May 1	7,300,000	Off St. Catherine's.
„ 4	5,400,000	Two miles below Inveraray.
„ 11	3,500,000	Off Inveraray.
	51,350,000	
	142,880,000	
1902.		
April 22	7,200,000	Between Inveraray and Strachur.
„ 28	8,700,000	„ „ „
	15,900,000	

The total number in the six years, 1896-1901, during which push-netting was carried on, amounted to 142,880,000, but a deduction must be made for a small amount of loss which occurred during transit, and which cannot be well estimated. The fry, as a general rule, were very lively when liberated, and could be observed swimming in the water in a natural way, but occasionally, when the temperature of the water in the vessels in which they had been carried was higher than usual, the movements of some of them were more feeble.

After the fry are liberated they lead a pelagic life, that is to say, they swim about suspended in the water and are carried about by it, if it is in movement, and, as already stated, the duration of this period is somewhat over four weeks. At the end of this time they settle on the sandy beaches in shallow water, as little, completely, or almost completely, transformed flat-fishes, and they may be found in such localities from the latter part of May onwards. The spawning period of the plaice naturally existing in Lochfyne was found to correspond closely with the spawning period in the pond at the hatchery, and there is no means of discriminating between the young plaice derived from the fry put into the loch and those derived from eggs which were spawned naturally in the neighbourhood. The only way of determining the effect of the addition of fry on the abundance of the young plaice found on the beaches was by making a series of observations in a regular and systematic way to ascertain their numbers, as described below, in years when fry were added and in years when fry were not added, and when, therefore, the number of the young plaice was derived from local spawning. As already stated, fry were added in each of the seven years 1896-1902, while no fry were added in the six years 1903-1908. The observations to determine the abundance of the young plaice on the beaches were made in each of the years, with the exception of 1902, so that there are observations in six successive years when plaice fry were put into the loch and in six successive years when none were put in.

In order to ascertain the number of the young plaice on the beaches various methods were at first tried. A fine-meshed ground seine was employed at various parts of the loch, but the results were unsatisfactory; it frequently got caught on stones, &c., on the beach and was torn, and comparatively few plaice were taken, so that this method was abandoned. A method which would probably have been satisfactory was the use of a small-meshed shrimp-trawl net, and this was also tried, but it was found that it could not be used in the shallow water in Lochfyne, near enough to the tidal margin, which is frequented by the young plaice, and it had to be given up. A specially-constructed trap-net was also tried, but without success, and the method which was found to give the best results, and the one adopted, was a shove- or push-net, like the similar net used in some places for catching shrimps, and of the following dimensions :— Length of wooden scraper, 3 feet 6 inches; breadth of same, 3 inches; height of iron frame, 20 inches; length of net, 7 feet 6 inches; mesh of end part, about 7 mm. in diameter; length of pole, 10 feet. Certain localities were selected, after trials had been made, and the net was pushed along the bottom at each "station" for a certain length of time, usually two hours, in a foot or two of water and at low tide, when the young plaice are found near the margin in greatest numbers. Several of the stations which were at first made use of were subsequently abandoned, as Lowburn, Cairndow, Otter Spit, because it was found that the numbers obtained were small; and whereas at first the push-netting was made in various months of the year, it was found necessary later for the same reason, to limit the work to the summer months, and the comparison

made between the results in the two periods of six years is limited to those months and to the five stations shown on the chart (Pl. II.) and in the tables.

The contents of the net on each occasion were placed in a pail of water, and the fishes carefully picked out from the weeds, &c., a process which not infrequently occupied some time. They were then preserved in bottles and brought to the Laboratory, where they were examined and the plaice counted and measured. The conditions at each station as to temperature, weather, &c., were recorded, and the particulars will be found detailed in Table V., page 70.

9. The Results.

In Table IV. will be found the records of the plaice taken in the push-net at each of the stations, the measurements being arranged in groups of three millimetres; in the other tables the results are summarised, and the average number of the young plaice of the year, per one hour's fishing, are given for each collection at each station. As a rule there is no difficulty in separating the plaice of the year from those of the year before by the examination of the measurements, but in a few cases there may be a little doubt whether a particular fish of the larger sizes should be placed in one or other of the two classes. It will be seen that such cases, however, are of little or no importance as regards the average, and would not alter it to an appreciable extent. The collective results of the push-netting may be stated as follows, the total number of the year's plaice obtained being 13,068, and the aggregate number of hours fishing being 239½:—

	No. of Fry Liberated.	No. of Hours Fishing.	No. of Year's Plaice taken.	Average No. per Hour.
1st Period, 1896–1901,	142,880,000	74	6,491	87·7
2nd Period, 1903–1908,	None.	165½	6,577	39·7

It will be seen that in the first period, when plaice fry were being put into the loch, the average number of young plaice of the year which were taken per hour's fishing was 87·7, while in the second period, when no fry were added, the average was only 39·7, or less than half.

The results for the various years differed considerably, as is shown in the following Table:—

[Table.

Year.	No. of Fry Liberated.	Duration of Fishing.	No. of Plaice taken.	Average No. per Hour.
		Hrs. Mins.		
1896	4,100,000	10 0	1,114	111·4
1897	21,170,000	2 30	60	24·0
1898	19,200,000	12 30	1,195	95·6
1899	16,470,000	17 0	488	28·7
1900	30,590,000	16 0	850	53·1
1901	51,350,000	16 0	2,784	174·0
1903	None.	33 0	1,231	37·3
1904	None.	31 45	253	8·0
1905	None.	29 45	3,333	112·0
1906	None.	30 25	505	16·6
1907	None.	8 50	294	33·3
1908	None.	31 45	961	30·3

The figures given above refer to all the stations combined and to all the collections in each year and in the two periods, but it is necessary to consider the results at each of the stations, and also the results in the different months in which collections were made. The total number of the year's brood of plaice and the average number taken in each hour's fishing in the two periods were as follow:—

	Lochgilphead.		Big Harbour.		Salen.		Strachur.		Inveraray.	
	No. of Plaice.	Average per Hour.	No. of Plaice.	Average per Hour.	No. of Plaice.	Average per Hour.	No. of Plaice.	Average per Hour.	No. of Plaice.	Average per Hour.
1st Period, 1896-1901,	336	56·0	2178	101·4	1079	166·0	1132	58·1	1766	86·1
2nd Period, 1903-1908,	962	36·8	2221	57·6	1840	61·3	938	26·1	616	17·7
Decrease per Hour,	...	19·2	...	43·8	...	104·7	...	32·0	...	68·4

The figures show that the average number of plaice per hour at each of the five stations was less in the second period than in the first, that is when the collective results in all the months are considered together.

The months in which the collections dealt with in the tables were made were June, July, August, and September, but for various reasons the amount of fishing in these months in the two periods was not always equal. In June only one series of collections were obtained in the first period, whereas in the second period five collections were made; a circumstance which very much reduces the value of the comparison for that month. The detailed averages are given in Table III., and the means are as follow:—

	Lochgilp-head.	Big Harbour.	Salen.	Strachur.	Inveraray.	Mean.
1st Period, 1899,	26·0	39·2	60·0	28·0	23·2	31·6
2nd Period, 1903,1904, 1906-1908,	29·7	28·25	31·0	28·5	11·2	26·0

In July, however, the number of collections was not only large but there was in each period five collections in this month, in all the years of the first period except 1899 and in all those of the second period except 1907, and it was in this month that the largest number of fish were taken, amounting to over 60 per cent. of the whole. The mean number of plaice taken per hour at each station in the two periods is shown as follows:—

	Lochgilp-head.	Big Harbour.	Salen.	Strachur.	Inveraray.	Mean.
1st Period,	70·2	146·0	208·0	87·1	150·5	130·2
2nd Period,	30·1	96·4	99·8	29·4	28·0	56·1

There was thus a very considerable reduction of the average number per hour's fishing at each of the stations, and the mean reduction amounted to 74 fish per hour. The detailed averages are given in the table, page 64, and are discussed below.

In August, collections were obtained in seven of the years, namely, in 1899 and 1901 in the first period, and in all the years of the second period except 1907. About 20 per cent. of the total number of plaice obtained were taken in this month, and the mean number per hour's fishing at each station is as follows:—

	Lochgilp-head.	Big Harbour.	Salen.	Strachur.	Inveraray.	Mean.
1st Period, 1899,1901,	36·0	75·8	75·0	27·8	27·6	45·9
2nd Period,	34·6	40·0	74·9	25·9	12·9	36·6

The reduction in the average number in this month was much less, and at one station—Salen—the averages were practically identical. The details are given in Table III., but the comparison is of less value than in August, for the reason stated, there being nine collections in the two years of the first period as compared with twenty-three collections in the five years of the second period.

In September there were two collections in each period, in 1898 and 1900 in the first, and in 1903 and 1905 in the second. The average number of plaice taken at each station in the two periods is as follows:—

	Lochgilp-head.	Big Harbour.	Salen.	Strachur.	Inveraray.	Mean.
1898,1900,	24·0	60·2	142·0	27·2	21·7	47·0
1903,1905,	99·0	65·1	13·7	13·6	13·0	35·9

The reduction is small here also, and at two of the stations the average in the last period is higher than in the first. It may be noted, however, that in the second period there was only one collection made in this month at Lochgilphead and that was in the most productive year of the period—1905.

We may now consider the averages resulting from a combination of the months, bearing in mind the remarks above made as to the proportion in the two periods.

In June and July, representing about 71 per cent. of the total fish, the averages in the two periods were as follow :—

	Lochgilp-head.	Big Harbour.	Salen.	Strachur.	Inveraray.	Mean.
1st Period,	65·3	124·6	191·5	75·1	125·0	112·2
2nd Period,	29·9	64·3	65·4	28·9	21·1	42·1

In July and August together, representing about 80 per cent. of the total number of fish taken, the averages for the various stations were :—

	Lochgilp-head.	Big Harbour.	Salen.	Strachur.	Inveraray.	Mean.
1st Period,	66·4	122·6	181·4	68·6	109·5	105·2
2nd Period,	32·5	69·3	87·2	27·7	20·9	46·6

In August and September, representing about 29 per cent. of the total quantity of fish taken, the various averages were as follow :—

	Lochgilp-head.	Big Harbour.	Salen.	Strachur.	Inveraray.	Mean.
1st Period,	28·0	68·9	108·5	27·6	25·4	46·7
2nd Period,	46·6	48·2	55·9	22·1	12·8	36·4

10. Discussion of Results.

From the consideration of the averages as above discussed it is clear that the number of young plaice of the year which were taken per hour's fishing by the push-net in the first period of six years, when plaice fry were being added to the waters of Lochfyne, was much higher than in the second period of six years, when no fry were added. When the mean of all the collections made in the first six years is compared with the mean of all those taken in the second six years, the decrease was by more than half, amounting to 48 plaice per hour's fishing. The decrease was, moreover, common to all the five stations where collections were made, though it differed in degree, varying from 19·2 per hour to 104·7 per hour. When the collections in the same month throughout the two periods are studied, the same thing is brought out—a decrease in the mean number of plaice taken in the two periods, and, with a few exceptions, a decrease also at each of the stations. In July, in which the number of collections in the two periods were almost the same, in which the same number of years are included, and in which over 60 per cent. of the total number of plaice were obtained, the value of the comparison is greatest. The mean number per hour in that month for all the stations combined was 130·2 in the first period and 56·1 in the second period, a reduction of 74 fish per hour; and there was a notable diminution at each of the stations, varying from 40·1 to 122·5 fish per hour. In August, when two collections were made in the first period and five in the second, the fish obtained representing about 20 per cent. of the total, the mean reduction for all stations was a little under 10 plaice per hour's fishing, and there was a diminution at all stations except one, where the numbers were practically the same. In September the

basis of comparison is less extensive; the mean reduction was 11 plaice per hour, and two of the stations showed an increase in the second period.

It will be observed from the tables giving the detailed averages for each of the collections that the fluctuations at any station from month to month and year to year were considerable. The mean annual average number of plaice per hour's fishing varied in the first period from 24 to 174, and in the second period from 8 to 112. In the month of June the mean, for all the stations combined, fluctuated in different years from 10·2 to 33·4; in July the mean varied from 24 to 266·8 in the first period and from 8·7 to 172 in the second period; in August it varied from 5 to 112, and in September from 22 to 54. At the individual stations the fluctuations were still greater, as shown in the tables. Fluctuations in quantity in this way are, of course, prominent in all fishing operations. Thus, in the trawling experiments of the "Garland," in the Firth of Forth, the fluctuations in the average catch per hour's trawling at the same station in the same month of different years varied for plaice from 1 to 44, for dabs from 0 to 112, for haddocks from 0 to 296, and for whitings from 0 to 50. But the means for all the observations in a year were much less, namely, for plaice from 5·9 to 9, for dabs from 4·4 to 8·6, for haddocks from 3·3 to 26·9, and for whitings from 2·2 to 14·4. It would be of importance to determine, if possible, whether the fluctuations in the take per hour were representative of the fluctuations in the natural abundance of the young plaice at the stations on the various occasions when fishing was carried on. A study of the particulars as to the physical conditions prevailing when the collections were made does not appear to show that they had much influence on the averages. It might be expected that when the water was clear the average would be reduced, because of the visibility of the approaching push-net to many of the young plaice, but many of the best catches were taken under such conditions, and the work was not prosecuted if the weather was rough. It is to be noted that, as a rule, when the average was high at one station or in one month it was also high at the other stations and in the succeeding month. Thus the most productive year in the first period was 1901, and the average in each month and for each station was very high, higher than in any other year of the period, except at Lochgilphead in July. In the second period the most productive year was 1905, and here again the averages at each of the stations and in each month were very high—the highest for any year in the period except at Big Harbour in August. So also in the years of low means, the averages at each of the stations and in each of the months were as a rule low. This may be illustrated by contrasting the averages for 1904 and 1905 as follows:—

	Lochgilphead.	Big Harbour.	Salen.	Strachur.	Inveraray.	Mean.
1904—June,	—	21·6	5·6	10·0	2·0	10·2
July,	3·0	10·8	12·8	9·8	8·4	9·2
August,	1·6	5·5	8·8	3·3	4·4	4·9
1905—July,	83·0	332·0	230·9	104·5	90·7	172 0
August,	118·1	54·5	252·0	64·5	45·6	112·0
September,	99·0	97·5	18·5	18·5	14·5	49·6

From this general uniformity at the various stations and in the different months of a year, it may be concluded that the averages represent approximately an actual abundance or scarcity of the young plaice on the beaches in Lochfyne in that year, and that they are not due to accidental or temporary circumstances.

Owing to the great natural fluctuations that occur, as shown, for example, in the means for the second period, when no plaice fry were added, one would not expect that the fluctuations in abundance in the years when plaice fry were added would be closely related to the number of fry liberated in any particular year, for the increase due to this cause is liable to be masked by the extent of this natural fluctuation. In the twelve years for which annual averages exist, four of the six highest were in the first period of six years and two in the last six. The highest of all was in the year when the greatest number of plaice fry were added, viz., 1901, when the average was 174 per hour and when 51,350,000 fry were liberated. The second highest was in 1905, when no fry were added, the average being 112 per hour. The third highest was in 1896, viz., 111·4 per hour, when 4,100,000 fry were added; the fourth highest was in 1898, viz., 95·6 per hour, when 19,200,000 fry were placed in the loch; the fifth highest, 53·1, per hour, was in 1900, when the number of fry liberated was 30,590,000; the sixth highest, 37·3 per hour, was in 1903, when no fry were added.

The period of thirteen years over which these experiments have extended is considerable, and ought to go far to equalise the natural fluctuations; and I think it is reasonable to conclude that the greatly increased average abundance of the young plaice in the first six years was mainly due to the liberation of the 142,880,000 fry of the plaice in those years, and that, on the other hand, the decrease in the abundance of young plaice in the last six years was mainly owing to the fact that no plaice fry were added to the waters of the loch in that period. On theoretical grounds alone it would be an astonishing thing if the addition of the immense number of plaice larvæ mentioned to the waters of a long, narrow, and confined loch like Lochfyne should produce no increase in the numbers of young plaice a few months older than the larvæ added. And if that is the effect in Lochfyne, it will also be the effect elsewhere, though the natural fluctuations may conceal it. With regard to the extent of the influence of the liberation of the fry on the abundance of the young plaice during these experiments, the difference in the averages in the two periods shows that the plaice were more than doubled in number.* There is one consideration, however, that ought not to be lost sight of. On the East Coast, and in the North Sea generally, there have been complaints of the diminution of plaice in recent years, and this was proved to have occurred in the Firth of Forth from the trawling experiments of the "Garland." There is not sufficient information with regard to the Clyde area to show whether the same change is occurring there, but if it is—if the adult plaice are decreasing and have been for some years decreasing—it might account, in part at least, for the reduction in the average catch of the young plaice in Lochfyne in the second period of the experiments. It would therefore be desirable to have a third period in the experiments, namely, a series of years during which large numbers of plaice fry were added to the waters of the loch, as in the first period, and to ascertain the effect of this on the abundance of the young plaice on the beaches.

* The above conclusion with regard to the result of the experiments in Lochfyne—that the number of plaice on the beaches was more than doubled by the addition of the artificially-hatched fry—has been confirmed by an elaborate mathematical investigation of the fluctuations in the different years, which was kindly made by Miss R. M. Lee, of the Marine Biological Laboratory, Lowestoft, after my paper had gone to the printer.—T.W.F.

TABLE I.—Showing the Time of Fishing and the Number of the Season's Plaice caught at each Station.

Date.	Lochgilphead.		Big Harbour.		Salen.		Strachur.		Inveraray.		Total.	
	Mins.	Fish.	Mins.	Fish.	Mins.	Fish.	Mins.	Fish.	Mins.	Fish.	Mins.	Fish.
1896.												
July	120	41	120	336	120	421	120	166	120	150	600	1114
1897.												
July	30	16	30	21	30	6	30	7	30	10	150	60
1898.												
July	30	138	150	356	30	58	150	53	150	374	510	979
Sept.	30	14	120	83	30	86	30	2	30	31	240	216
1899.												
June	30	13	150	98	30	30	150	70	150	58	510	269
Aug.	30	18	150	127	30	23	150	46	150	5	510	219
1900.												
July	30	29	150	220	30	102	150	104	150	71	510	526
Sept.	30	10	120	158	30	56	120	66	150	34	450	324
1901.												
July	30	57	150	527	30	245	150	539	150	900	510	2268
Aug.	...	...	150	252	30	52	120	79	150	133	450	516
	360	336	1290	2178	390	1079	1170	1132	1230	1766	4440	6491
1903.												
June	30	13	120	25	...	...	120	93	120	86	390	217
July	...	...	180	291	...	...	160	49	210	105	550	445
Aug.	...	...	150	260	...	...	150	43	150	49	450	352
Sept.	...	...	200	152	120	18	150	24	120	23	590	217
1904.												
June	...	...	150	54	150	14	120	20	120	4	540	92
July	120	6	150	27	150	32	135	22	150	21	705	108
Aug.	150	4	120	11	150	22	90	5	150	11	660	53
1905.												
July	120	166	135	747	125	481	120	209	125	189	625	1792
Aug.	125	246	120	109	120	504	120	129	75	57	560	1045
Sept.	120	198	120	195	120	37	120	37	120	29	600	496
1906.												
June	130	97	120	73	120	110	120	4	120	3	610	287
July	120	33	120	11	120	24	135	18	120	3	615	89
Aug.	120	16	120	25	120	31	120	54	120	3	600	129
1907.												
June	140	41	120	127	135	69	135	57	...	...	530	294
1908.												
June	135	64	130	29	110	73	110	113	140	...	625	279
July	130	41	120	57	120	320	120	29	120	20	610	467
Aug.	130	37	140	28	140	105	130	32	130	13	670	215
	1570	962	2315	2221	1800	1840	2155	938	2090	616	9930	6577

TABLE II.—Showing the Average Number of the Season's Plaice per Hour of Fishing at each Station.

Date.	Loch-gilphead.	Big Harbour.	Salen.	Strachur.	Inver-aray.	Mean.
1896.						
July - - -	20·5	168·0	210·5	83·0	75·0	111·4
1897.						
July - - -	32·0	42·0	12·0	14·0	20·0	24·0
1898.						
July - - -	276·0	142·4	116·0	21·2	149·6	115·2
September - -	28·0	41·5	172·0	4·0	62·0	54·0
1899.						
June - - -	26·0	39·2	60·0	28·0	23·2	31·6
August - -	36·0	50·8	46·0	18·4	2·0	25·8
1900.						
July - - -	58·0	88·0	204·0	41·6	28·4	61·9
September - -	20·0	79·0	112·0	33·0	13·6	43·2
1901.						
July - - -	114·0	210·8	490·0	215·6	360·0	266·8
August - -	...	100·8	104·0	39·5	53·2	68·8
Average -	56·0	101·4	166·0	58·1	86·1	87·7
1903.						
June - - .	26·0	12·5	...	46·5	43·0	33·4
July - - -	...	97·0	...	18·4	30·0	48·5
August - -	...	104·0	...	17·2	19·6	46·9
September - -	...	45·6	9·0	9·6	11·5	22·1
1904.						
June - - -	...	21·6	5·6	10·0	2·0	10·2
July - - -	3·0	10·8	12·8	9·8	8·4	9·2
August - -	1·6	5·5	8·8	3·3	4·4	4·9
1905.						
July - - -	83·0	332·0	230·9	104·5	90·7	172·0
August - -	118·1	54·5	252·0	64·5	45·6	112·0
September - -	99·0	97·5	18·5	18·5	14·5	49·6
1906.						
June - - -	44·8	36·5	55·0	2·0	1·5	28·2
July - - -	16·5	5·5	12·0	8·0	1·5	8·7
August - -	8·0	12·5	15·5	27·0	1·5	12·9
1907.						
June - - -	17·6	63·5	30·7	25·3	...	33·3
1908.						
June - - -	28·4	13·4	39·8	61·6	0·0	26·8
July - - -	18·9	28·5	160·0	14·5	10·0	45·9
August - -	17·1	12·0	45·0	14·8	6·0	19·3
Average -	36·8	57·6	61·3	26·1	17·7	39·7

TABLE III.—Showing the Average Number of Season's Plaice taken per Hour in June, July, August, and September in the two periods 1896-1901 and 1903-1908.

Date.	Loch-gilphead.	Big Harbour.	Salen.	Stra-chur.	Inver-aray.	Mean.
June.						
1899 - - -	26·0	39·2	60·0	28·0	23·2	31·6
July.						
1896 - - -	20·5	168·0	210·5	83·0	75·0	111·4
1897 - - -	32·0	42·0	12·0	14·0	20·0	24·0
1898 - - -	276·0	142·4	116·0	21·2	149·6	115·2
1900 - - -	58·0	88·0	204·0	41·6	28·4	61·9
1901 - - -	114·0	210·8	490·0	215·6	360·0	266·8
	70·2	146·0	208·0	87·1	150·5	130·2
August.						
1899 - - -	36·0	50·8	46·0	18·4	2·0	25·8
1901 - - -	...	100·8	104·0	39·5	53·2	68·8
	36·0	75·8	75·0	27·8	27·6	45·9
September.						
1898 - - -	28·0	41·5	172·0	4·0	62·0	54·0
1900 - - -	20·0	79·0	112·0	33·0	13·6	43·2
	24·0	60·2	142·0	27·2	21·7	47·0
June.						
1903 - - -	26·0	12·5	...	46·5	43·0	33·4
1904 - - -	...	21·6	5·6	10·0	2·0	10·2
1906 - - -	44·8	36·5	55·0	2·0	1·5	28·2
1907 - - -	17·6	63·5	30·7	25·3	...	33·3
1908 - - -	28·4	13·3	39·8	61·6	0·0	26·8
	29·7	28·2	31·0	28·5	11·2	26·0
July.						
1903 - - -	...	97·0	...	18·4	30·0	48·5
1904 - - -	3·0	10·8	12·8	9·8	8·4	9·2
1905 - - -	83·0	332·0	230·9	104·5	90·7	172·0
1906 - - -	16·5	5·5	12·0	7·5	1·5	8·7
1908 - - -	18·9	28·5	160·0	14·5	10·0	46·0
	30·1	96·4	99·8	29·4	28·0	56·1
August.						
1903 - - -	...	104·0	...	17·2	19·6	46·9
1904 - - -	1·6	5·5	8·8	3·3	4·4	4·9
1905 - - -	118·1	54·5	252·0	64·5	45·6	112·0
1906 - - -	8·0	12·5	15·5	27·0	1·5	12·9
1908 - - -	17·1	12·0	45·0	14·8	6·0	19·2
	34·6	40·0	74·9	25·9	12·9	36·6
September.						
1903 - - -	...	45·6	9·0	9·6	11·5	22·1
1905 - - -	99·0	97·5	18·5	18·5	14·5	49·6
	99·0	65·1	13·7	13·6	13·0	35·9

TABLE IV.—Showing the Measurements of the Plaice in the various Collections at each Station.—I. LOCHGILPHEAD.

Mm.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.	32.
	1896—8th July. 2 h. 0 m.	1896—17th Nov. 0 h. 30 m.	1897—31st July. 0 h. 30 m.	1897—11th Oct. 0 h. 30 m.	1897—18th Nov. 0 h. 30 m.	1898—15th Feb. 0 h. 30 m.	1898—22nd April. 0 h. 30 m.	1898—1st July. 0 h. 30 m.	1898—20th Sept. 0 h. 30 m.	1898—19th Dec. 0 h. 30 m.	1899—25th April. 0 h. 30 m.	1899—26th June 0 h. 30 m.	1899—10th Aug. 0 h. 30 m.	1899—23rd Oct. 0 h. 30 m	1900—18th April. 0 h. 30 m.	1900—26th July. 0 h. 30 m.	1900—12th Sept. 0 h. 30 m.	1900—4th Dec. 0 h. 30 m.	1901—2nd July. 0 h. 30 m.	1903—26th June. 0 h. 30 m.	1904—30th July. 2 h. 0 m.	1904—18th Aug. 2 h. 30 m.	1905—5th July. 2 h. 0 m.	1905—15th Aug. 2 h. 5 m	1905—16th Sept. 2 h. 0 m.	1906—22nd June. 2 h. 10 m.	1906—23rd July 2 h. 0 m.	1906—21st Aug. 2 h. 0 m.	1907—1st July. 2 h. 20 m.	1908—13th June. 2 h. 15 m.	1908—13th July. 2 h. 10 m.	1908—14th Aug. 2 h. 10 m.
10- 12	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13- 15	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	2	-	-	1	-	-	-	-	-	-
16- 18	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	1	-	-	11	-	-	-	-	-	-	1	-	-
19- 21	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	4	-	-	26	-	-	3	2	-	-	3	-	-
22- 24	2	-	-	-	-	-	-	1	-	-	-	-		-	-	-	-	-	1	-	-	-	16	-	-	2	1	-	1	3	1	-
25- 27	3	-	-	-	-	-	-	4	-	-	-	2		-	-	-	-	-	2	-	-	-	27	-	-	12	2	-	1	13	3	1
28- 30	3	-	-	-	-	-	-	5	-	-	-	-		-	-	-	-	-	6	2	-	-	25	4	-	16	3	-	3	13	3	1
31- 33	7	-	2	-	-	-	-	14	-	-	-	2		-	-	-	-	-	10	1	-	-	27	4	-	29	1	-	5	17	4	4
34- 36	8	-	-	-	-	-	-	13	-	-	-	1		-	-	-	-	-	6	2	-	-	14	18	6	16	2	-	7	11	9	3
37- 39	3	-	1	-	-	-	-	9	-	-	-	2		-	-	2	-	-	6	-	-	-	9	42	24	10	1	-	9	2	6	3
40- 42	5	-	5	-	-	-	-	12	-	-	-	3		-	-	3	-	-	10	1	1	-	4	42	28	8	2	-	3	1	3	2
43- 45	4	-	2	-	-	-	-	18	-	-	-	2		-	-	4	2	-	6	1	-	1	2	57	41	3	2	2	4	-	4	2
46- 48	2	-	1	-	1	1	-	26	-	-	-	-		-	-	4	2	-	7	1	-	-	1	36	30	2	3	1	-	-	-	6
49- 51	3	-	1	-	-	-	-	22	1	-	-	1		-	-	4	2	-	2	-	-	-	-	27	22	-	2	-	2	-	2	2
52- 54	1	-	-	1	1	-	-	6	1	-	-	-		-	-	3	1	1	1	-	2	1	2	6	14	-	3	-	2	-	2	2
55- 57	1	-	1	1	-	-	-	8	2	2	-	-		-	-	4	2	-	-	-	2	-	-	-	18	-	7	1	-	-	1	2
58- 60	3	-	3	-	1	-	-	-	3	-	-	-		-	-	4	-	2	-	-	-	-	-	4	6	-	1	2	1	-	-	3
61- 63	1	-	-	2	3	2	-	-	1	-	-	-		4	-	1	1	-	-	-	-	-	-	2	2	-	-	4	3	-	3	1
64- 66	-	-	-	-	-	-	-	-	2	1	-	-		-	-	-	-	-	-	-	-	-	-	1	2	-	1	2	-	-	-	2
67- 69	-	-	-	-	1	-	1	-	-	2	-	-		-	-	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	2
70- 72	-	-	-	-	1	-	-	-	2	1	-	-		1	-	-	-	1	-	-	-	-	-	1	1	-	-	-	-	-	-	-
73- 75	-	-	-	-	1	-	-	-	-	-	-	-		-	-	-	-	-	-	-	1	-	-	-	1	-	-	3	-	-	-	1
76- 78	-	-	-	-	1	-	-	-	-	1	-	-		1	1	-	-	1	-	-	-	-	-	-	2	-	-	1	-	-	-	-
79- 81	-	-	-	3	-	1	-	-	1	1	1	-		2	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
82- 84	-	-	-	-	-	1	1	-	-	-	-	-		1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
85- 87	-	-	-	-	-	-	-	-	-	1	-	-		1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
88- 90	-	-	-	-	-	-	1	-	1	2	-	-	18 not measured.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
91- 93	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
94- 96	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
97- 99	-	-	-	-	-	-	-	-	-	2	-	-		1	1	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
100-102	-	-	-	-	-	-	-	-	-	-	-	-		-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
103-105	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
106-108	-	-	-	-	-	1	-	-	-	-	-	-		1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
109-111	-	-	-	-	-	-	-	-	-	-	-	-		-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
112-114	-	-	-	-	-	-	-	1	-	-	-	-		1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
115-117	-	-	-	-	-	-	-	-	-	-	-	1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
118-120	-	-	-	-	-	-	-	-	-	-	-	1		-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-
121-123	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
124-126	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
127-129	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
130-132	-	-	1	-	-	-	-	-	-	-	-	-		-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
133-135	-	-	-	-	-	-	-	-	-	-	-	1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
136-138	-	-	1	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
139-141	-	-	-	1	-	-	1	-	-	-	1	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
142-144	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
145-147	-	1	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
148-150	-	-	-	-	-	-	-	-	1	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
151-153	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
154-156	-	-	-	-	-	-	-	-	-	-	-	-		-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
157-159	-	-	-	-	-	*	-	-	-	-	-	-		-	-	-	†	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

* One 164. † One 178; one 182.

TABLE IV. (*continued*)—II. BIG HARBOUR.

Mm.	1. 1896—11th July. 2 h. 0 m.	2. 1896—17th Nov. 2 h. 0 m.	3. 1896—22nd Dec. 2 h. 0 m.	4. 1897—30th Mar. 2 h. 0 m.	5. 1897—27th July. 0 h. 30 m.	6. 1897—12th Oct. 0 h. 30 m.	7. 1897—20th Nov. 2 h. 30 m.	8. 1898—25th Feb. 2 h. 0 m.	9. 1898—1st March. 0 h. 30 m.	10. 1898—15th April. 2 h. 0 m.	11. 1898—20th April. 0 h. 30 m.	12. 1898—29th June. 2 h. 30 m.	13. 1898—29th Sept. 2 h. 0 m.	14. 1898—20th Dec. 1 h. 45 m.
10- 12	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13- 15	-	-	-	-	-	-	-	-	-	-	-	1	-	-
16- 18	-	-	-	-	-	-	-	-	-	-	-	3	-	-
19- 21	-	-	-	-	-	-	-	-	-	-	-	3	-	-
22- 24	7	-	-	-	-	-	-	-	-	-	-	16	-	-
25- 27	27	-	-	-	-	-	-	-	-	-	-	36	-	-
28- 30	58	-	-	-	-	-	-	-	-	-	-	81	-	-
31- 33	32	-	-	-	1	-	-	-	-	-	-	77	-	-
34- 36	17	-	-	-	1	-	-	-	-	-	-	45	-	-
37- 39	34	-	-	-	2	-	-	-	-	-	-	28	-	-
40- 42	35	-	-	-	2	-	-	-	-	-	-	19	2	-
43- 45	22	-	1	-	4	-	-	-	-	-	-	11	3	-
46- 48	29	-	1	-	2	-	-	-	-	-	-	13	4	-
49- 51	21	1	1	-	5	-	-	-	-	-	-	10	6	-
52- 54	22	3	7	-	2	-	-	-	-	-	-	5	5	-
55- 57	16	3	6	2	-	-	-	-	-	-	-	3	4	2
58- 60	4	1	8	1	2	1	-	-	-	-	-	2	16	2
61- 63	6	7	9	5	-	2	1	-	-	-	-	2	6	5
64- 66	4	3	2	5	-	1	-	-	-	-	-	1	9	2
67- 69	1	3	1	4	-	2	3	-	-	-	-	-	7	-
70- 72	1	3	6	-	-	1	1	-	-	-	-	-	8	-
73- 75	-	5	1	1	-	-	4	-	-	-	-	-	4	1
76- 78	-	3	1	-	-	-	2	-	-	-	-	-	2	3
79- 81	-	2	4	5	-	-	5	-	-	-	-	-	-	2
82- 84	-	4	1	4	-	1	4	-	-	-	-	-	1	2
85- 87	-	3	2	4	-	-	3	-	-	-	-	-	1	1
88- 90	-	4	-	-	-	-	-	-	-	-	-	-	-	-
91- 93	-	1	-	-	-	1	4	1	-	-	-	-	2	-
94- 96	-	2	1	-	-	-	4	-	-	-	-	-	2	-
97- 99	-	-	1	1	-	-	1	-	-	1	-	-	1	-
100-102	-	-	-	-	-	1	2	1	-	-	-	-	-	-
103-105	-	2	-	6	-	-	-	1	-	-	-	-	-	-
106-108	-	1	-	2	-	-	2	-	-	-	-	-	-	-
109-111	-	1	-	2	-	-	2	1	-	-	-	-	-	1
112-114	-	1	-	2	-	-	1	-	-	-	-	1	-	-
115-117	-	-	-	-	-	-	1	-	-	1	-	-	-	-
118-120	-	1	-	1	-	-	-	-	-	-	-	-	-	-
121-123	-	3	-	-	-	-	1	-	-	1	-	-	-	-
124-126	-	1	-	-	-	-	1	-	-	-	1	-	-	-
127-129	-	-	-	1	-	-	-	-	-	-	-	-	-	-
130-132	-	1	-	1	-	-	-	-	-	-	-	-	-	-
133-135	-	-	-	-	-	-	1	-	-	-	-	-	-	-
136-138	-	-	-	-	-	-	-	-	-	-	-	-	-	-
139-141	-	-	-	-	-	-	-	-	-	-	-	-	-	-
142-144	-	-	-	-	-	-	-	-	-	-	-	-	-	-
145-147	-	-	-	1	-	-	-	-	-	-	-	-	-	-
148-150	-	-	-	-	-	-	1	-	-	-	-	-	-	-
151-153	-	-	-	-	-	-	-	-	-	-	-	-	-	-
154-156	-	-	-	-	-	-	-	1	-	-	-	-	-	-
157-159	-	*	-	-	-	†	-	-	1	-	-	-	-	‡

Mm.	15. 1899—11th Jan. 0 h. 30 m.	16. 1899—14th April. 2 h. 30 m.	17. 1899—23rd June. 2 h. 30 m.	18. 1899—10th Aug. 2 h. 30 m.	19. 1899—17th Oct. 0 h. 30 m.	20. 1900—26th July. 2 h. 30 m.	21. 1900—11th Sept. 2 h. 0 m.	22. 1900—6th Dec. 2 h. 0 m.	23. 1901—3rd July. 2 h. 30 m.	24. 1901—29th Aug. 2 h. 30 m.	25. 1903—25th June. 2 h. 0 m.	26. 1903—13th July. 3 h. 0 m.	27. 1903—25th Aug. 2 h. 30 m.	28. 1903—25th Sept. 3 h. 20 m.
10- 12	-	-	-	127 not measured.	-	-	-	-	-	-	-	-	-	-
13- 15	-	-	-		-	-	-	-	9	-	-	-	-	-
16- 18	-	-	-		-	3	-	-	19	-	2	-	-	-
19- 21	-	-	1		-	9	-	-	34	-	7	12	-	-
22- 24	-	-	1		-	7	-	-	72	-	12	25	-	-
25- 27	-	-	3		-	15	-	-	149	-	3	73	-	-
28- 30	-	-	6		-	16	-	-	119	-	1	85	-	-
31- 33	-	-	7		-	16	-	-	68	-	-	56	2	-
34- 36	-	-	10		-	6	-	-	28	1	-	19	12	1
37- 39	-	-	5		-	15	1	-	16	3	-	11	30	2
40- 42	-	-	19		-	14	3	-	7	15	-	3	38	6
43- 45	-	-	15		-	14	16	-	4	21	-	3	49	18
46- 48	-	-	15		-	23	23	1	-	33	-	3	37	19
49- 51	-	-	7		-	28	17	-	2	36	-	1	30	21
52- 54	1	-	7		-	22	10	2	-	43	-	-	18	21
55- 57	-	-	2		1	13	10	1	-	38	-	-	15	21
58- 60	-	-	-		1	7	14	2	-	26	-	-	9	18
61- 63	1	-	-		3	8	16	1	-	12	-	-	6	9
64- 66	1	1	-		-	2	14	1	-	8	-	-	5	8
67- 69	1	-	-		2	1	15	2	-	5	-	-	2	1
70- 72	-	2	-		-	1	10	1	-	4	-	-	1	3
73- 75	-	1	-		1	-	5	-	-	2	-	-	3	1
76- 78	1	1	-		2	-	2	-	-	2	-	-	3	-
79- 81	1	1	-		1	-	-	-	-	1	-	-	-	2
82- 84	-	-	-		3	-	-	1	-	1	-	-	-	-
85- 87	-	1	-		-	-	2	-	-	1	-	-	-	-
88- 90	-	-	-		1	-	-	-	-	-	-	-	-	1
91- 93	-	-	-		4	-	-	-	-	-	-	-	-	-
94- 96	1	1	-		2	-	-	1	-	-	-	-	-	-
97- 99	-	1	-		2	-	-	1	-	-	-	-	-	-
100-102	-	-	-		-	-	-	-	-	-	-	-	-	-
103-105	-	1	-		2	-	-	-	-	-	-	-	-	-
106-108	-	-	-		1	-	-	-	-	-	-	-	-	-
109-111	-	1	-		-	-	-	-	-	-	-	-	-	-
112-114	-	-	1		-	-	-	-	-	-	-	-	1	-
115-117	1	-	-		-	-	-	1	-	-	-	-	-	-
118-120	-	-	2		-	-	-	-	-	-	-	-	-	-
121-123	-	-	1		-	-	-	-	-	-	-	-	1	-
124-126	-	-	-		-	-	-	-	-	-	-	-	2	-
127-129	-	-	-		-	-	-	-	-	-	-	-	-	-
130-132	-	-	-		-	-	-	-	-	-	-	-	-	-
133-135	-	-	1		-	-	-	-	-	-	-	-	1	1
136-138	-	-	-		-	-	-	-	-	-	-	-	-	-
139-141	-	-	-		-	-	-	-	-	-	-	-	-	-
142-144	-	-	-		-	-	-	-	-	-	-	-	-	-
145-147	-	-	-		-	-	-	-	-	-	-	-	-	1
148-150	-	-	1		-	-	-	-	-	-	-	-	-	1
151-153	-	-	-		-	-	-	-	-	-	-	-	-	-
154-156	-	-	-		-	-	-	-	-	-	-	-	-	1
157-159	-	-	-		§	-	-	-	-	-	-	-	-	-

Mm.	29. 1904—28th June. 2 h. 30 m.	30. 1904—28th July. 2 h. 30 m.	31. 1904—17th Aug. 2 h. 0 m.	32. 1905—6th July. 2 h. 15 m.	33. 1905—15th Aug. 2 h. 0 m.	34. 1905—15th Sept. 2 h. 0 m.	35. 1906—23rd June. 2 h. 0 m	36. 1906—24th July. 2 h. 0 m.	37. 1906—21st Aug. 2 h. 0 m.	38. 1907—27th June. 2 h. 0 m.	39. 1908—13th June. 2 h. 10 m.	40. 1908—15th July. 2 h. 0 m.	41. 1908—11th Aug. 2 h. 20 m.	42.
10- 12	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13- 15	-	-	-	2	-	-	1	-	-	-	1	-	-	-
16- 18	4	-	-	12	-	-	1	-	-	-	-	-	-	-
19- 21	8	-	-	37	-	-	2	-	-	4	1	-	-	-
22- 24	6	-	-	43	1	-	5	-	-	8	-	-	-	-
25- 27	11	-	-	99	1	-	10	1	-	17	7	-	-	-
28- 30	9	-	-	185	1	-	12	2	-	37	9	3	3	-
31- 33	5	2	-	156	12	3	16	2	-	42	5	2	2	-
34- 36	6	2	-	108	24	22	14	1	-	13	2	13	4	-
37- 39	1	3	-	44	22	26	7	1	1	2	2	3	2	-
40- 42	2	4	-	29	18	41	3	-	2	-	1	18	6	-
43- 45	2	5	-	9	15	37	2	2	8	2	1	10	4	-
46- 48	-	3	5	10	5	11	-	-	5	2	-	4	-	-
49- 51	-	2	3	4	5	17	-	1	1	-	-	3	2	-
52- 54	-	1	-	5	2	9	-	1	1	-	-	-	1	-
55- 57	-	3	-	2	-	10	-	-	2	-	-	-	2	-
58- 60	-	1	1	2	2	3	-	-	1	-	-	-	-	-
61- 63	-	-	-	-	-	3	-	-	1	-	-	-	-	-
64- 66	-	-	-	-	-	2	-	-	-	-	-	-	2	-
67- 69	-	1	1	-	-	1	-	-	3	-	-	-	-	-
70- 72	-	-	1	-	-	2	-	-	-	-	-	-	-	-
73- 75	-	-	-	-	-	2	-	-	-	-	-	1	-	-
76- 78	-	-	-	-	-	-	-	-	-	-	-	-	-	-
79- 81	-	-	-	-	-	3	-	-	-	-	-	-	-	-
82- 84	-	-	-	-	1	2	-	-	-	-	-	-	-	-
85- 87	-	-	-	-	-	1	-	-	-	-	-	-	-	-
88- 90	-	-	-	-	-	-	-	-	-	-	-	-	-	-
91- 93	-	-	-	-	-	1	-	-	-	-	-	-	-	-
94- 96	-	-	-	-	-	-	-	-	-	-	-	-	-	-
97- 99	-	-	-	-	-	-	-	-	-	-	-	-	-	-
100-102	-	-	-	-	-	2	1	-	-	-	-	-	-	-
103-105	-	-	-	-	-	-	-	-	-	-	-	-	-	-
106-108	1	-	-	-	-	-	-	1	-	-	-	-	-	-
109-111	-	-	-	-	-	-	-	-	-	-	-	-	-	-
112-114	-	-	-	-	-	-	-	-	-	-	-	-	-	-
115-117	-	-	-	-	-	-	-	-	-	-	-	-	-	-
118-120	-	-	-	-	-	-	-	-	-	-	-	-	-	-
121-123	-	-	-	-	-	-	-	-	-	-	-	-	-	-
124-126	-	-	-	-	-	-	-	-	-	-	-	-	-	-
127-129	-	-	-	-	-	-	-	-	-	2	-	-	-	-
130-132	-	-	-	-	-	-	-	-	-	-	-	-	-	-
133-135	-	-	-	-	-	-	-	-	-	-	-	-	-	-
136-138	-	-	-	-	-	-	-	-	-	-	-	-	-	-
139-141	-	-	-	-	-	-	-	-	-	-	-	-	-	-
142-144	-	-	-	-	-	-	-	-	-	-	-	-	-	-
145-147	-	-	-	-	-	-	-	-	-	-	-	-	-	-
148-150	-	-	-	-	-	-	-	-	-	-	-	-	-	-
151-153	-	-	-	-	-	-	-	-	-	-	-	-	-	-
154-156	-	-	-	-	-	-	-	-	-	-	-	-	-	-
157-159	-	-	-	-	-	-	-	-	-	‖	-	-	-	-

* One 194. † One 160, and one 180. ‡ One 229. § One 167; one 170; one 179; one 182; one 273; one 305. ‖ One 225.

TABLE IV. (*continued*)—III. SALEN.

Mm.	1. 1896—10th July. 2 h. 0 m.	2. 1896—16th Nov. 2 h. 0 m.	3. 1897—30th Mar. 0 h. 30 m.	4. 1897—27th July. 0 h. 30 m.	5. 1897—13th Oct. 0 h. 30 m.	6. 1897—21st Nov. 0 h. 30 m.	7. 1898—28th Feb. 0 h. 30 m.	8. 1898—14th April. 0 h. 30 m.	9. 1898—28th June. 0 h. 30 m.	10. 1898—30th Sept. 0 h. 30 m.	11. 1898—22nd Dec. 0 h. 30 m.	12. 1899—11th Jan. 0 h. 30 m.	13. 1899—19th April. 0 h. 30 m.	14. 1899—20th June. 0 h. 30 m.	15. 1899—9th Aug. 0 h. 30 m.	16. 1899—31st Oct. 0 h. 30 m.	17. 1900—18th April. 0 h. 30 m.	18. 1900—25th July. 0 h. 30 m.	19. 1900—13th Sept. 0 h. 30 m.	20. 1900—5th Dec. 0 h. 30 m.	21. 1901—2nd July. 0 h. 30 m.	22. 1901—29th Aug. 0 h. 30 m.	23. 1903—25th Sept. 2 h. 0 m.	24. 1904—27th June. 2 h. 30 m.	25. 1904—29th July. 2 h. 30 m.	26. 1904—16th Aug. 2 h. 30 m.	27. 1905—4th July. 2 h. 5 m.	28. 1905—16th Aug. 2 h. 0 m.	29. 1905—14th Sept. 2 h. 0 m.	30. 1906—22nd June. 2 h. 0 m.	31. 1906—24th July. 2 h. 0 m.	32. 1906—22nd Aug. 2 h. 0 m.	33. 1907—27th June. 2 h. 15 m.	34. 1908—15th June. 1 h. 50 m.	35. 1908—15th July. 2 h. 0 m.	36. 1908—11th Aug. 2 h. 20 m.
10- 12	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
13- 15	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	1	-	-	-	-	-	1	-	-	2	-	-	-	-	3	-
16- 18	-	-	-	-	-	-	-	-	1	-	-	-	-	-		-	-	-	-	-	6	-	-	3	-	-	1	-	-	2	-	-	-	-	14	-
19- 21	3	-	-	-	-	-	-	-	2	-	-	-	-	1		-	-	-	-	-	14	-	-	-	-	-	25	-	-	13	-	-	-	10	21	-
22- 24	11	-	-	-	-	-	-	-	1	-	-	-	-	1		-	-	3	-	-	63	-	-	2	1	-	50	-	-	20	2	-	4	22	37	-
25- 27	25	-	-	-	-	-	-	-	12	-	-	-	-	1		-	-	1	-	-	72	-	-	6	5	-	102	-	-	13	-	1	19	13	97	-
28- 30	54	-	-	-	-	-	-	-	13	-	-	-	-	-		-	-	1	-	-	57	-	-	3	3	-	124	5	-	16	4	-	22	16	70	1
31- 33	57	-	-	-	-	-	-	-	10	-	-	-	-	1		-	-	7	-	-	17	-	-	-	1	-	90	19	-	16	3	1	18	8	33	5
34- 36	59	-	-	1	-	-	-	-	3	-	-	-	-	9		-	-	14	-	-	8	-	-	-	2	1	54	62	1	20	4	1	5	1	29	11
37- 39	53	-	-	-	-	-	-	-	5	-	-	-	-	4		-	-	7	-	-	1	-	-	-	4	-	23	130	3	2	3	1	1	2	6	9
40- 42	44	-	-	1	-	-	-	-	6	-	-	-	-	7		-	-	11	-	-	3	4	-	-	-	1	3	102	12	5	4	1	-	-	3	13
43- 45	49	-	-	2	-	-	-	-	5	-	-	1	-	3		-	-	9	3	-	-	3	-	-	5	1	2	82	7	1	2	2	-	-	3	15
46- 48	22	-	-	1	-	-	-	-	-	8	-	-	-	1		-	-	12	4	-	-	9	2	-	3	2	6	50	8	-	-	5	-	-	1	8
49- 51	33	2	-	-	-	-	-	-	-	6	1	-	-	2		-	-	15	9	-	3	19	2	-	4	2	-	27	4	-	-	1	-	-	2	5
52- 54	8	2	-	1	-	-	-	-	-	5	-	-	-	-		-	-	8	6	1	-	7	2	-	3	3	-	12	-	-	-	3	-	-	1	8
55- 57	1	3	-	-	-	-	-	-	-	11	1	1	-	-		-	-	7	8	2	-	7	1	-	-	4	-	6	-	-	2	2	-	-	-	13
58- 60	1	2	2	-	-	-	-	-	-	13	3	1	-	-		-	-	2	8	-	-	2	3	-	-	3	-	1	1	-	-	3	-	-	-	8
61- 63	1	1	-	-	-	-	-	-	-	16	2	1	-	-		-	-	3	5	1	-	-	4	-	-	2	-	1	-	-	-	2	-	-	-	3
64- 66	-	3	-	-	3	-	-	-	-	5	3	3	-	-		-	-	1	5	1	-	-	1	-	-	1	-	2	-	-	-	2	-	-	-	3
67- 69	-	1	-	-	-	2	-	-	-	3	3	-	1	-		-	-	-	2	3	-	-	2	-	-	1	-	4	1	-	-	3	-	-	-	2
70- 72	-	-	-	-	-	1	-	-	-	4	1	2	-	-		-	-	1	2	2	-	1	-	-	1	1	-	-	-	-	-	-	-	-	-	1
73- 75	-	-	-	-	-	3	-	-	-	4	2	1	1	-		-	-	-	2	5	-	-	1	-	-	-	-	1	-	-	-	2	-	-	-	-
76- 78	-	-	-	-	-	1	-	-	-	4	1	1	1	-		-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
79- 81	-	-	-	-	-	1	-	-	-	1	2	-	2	-	23 not measured.	1	-	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32- 84	-	1	-	-	-	-	-	-	-	3	-	-	-	-		-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
85- 87	-	-	-	-	-	1	-	-	-	1	-	-	-	-		-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
88- 90	-	1	-	-	-	-	-	-	-	-	-	2	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
91- 93	-	-	-	-	-	2	-	-	-	-	2	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
94- 96	-	-	-	-	-	-	1	-	-	1	1	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
97- 99	-	-	-	-	-	2	-	-	-	1	-	-	-	-		-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
100-102	-	1	-	-	-	-	1	-	-	-	-	-	-	-		-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
103-105	-	1	-	-	-	-	-	-	-	-	-	1	-	-		1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
106-108	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
109-111	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
112-114	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
115-117	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
118-120	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
121-123	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
124-126	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
127-129	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
130-132	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
133-135	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
136-138	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
139-141	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
142-144	-	-	-	-	-	-	1	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
145-147	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
148-150	-	-	-	-	-	-	-	-	-	-	-	-	-	-		1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
151-153	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
154-156	-	-	-	-	-	-	-	1	-	*	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	‡	-	-	-	-
157-159	-	-	-	-	-	-	-	1	-	1	-	-	-	-		-	†	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

* One 185. † One 204; one 220. ‡ One 164.

TABLE IV. (*continued*)—IV. STRACHUR.

Mm.	1. 1896—14th July. 2 h. 0 m.	. 1896—13th Nov. 2 h. 0 m.	3. 1897—2nd April. 0 h. 30 m.	4. 1897—30th July. 0 h. 30 m.	1897—8th Oct. 0 h. 30 m.	6. 1897—22nd Nov. 2 h. 30 m.	7. 1898—23rd Feb. 2 h. 30 m.	8. 1898—19th April. 2 h. 30 m.	9. 1898—12th July. 2 h. 30 m.	10. 1898—23rd Sept. 0 h. 30 m.	11. 1899—10th Jan. 0 h. 30 m.	12. 1899—24th April. 2 h. 30 m.	1899—21st June. 2 h. 30 m.
10- 12	-	-	-	-	-	-	-	-	-	-	-	-	-
13- 15	-	-	-	-	-	-	-	-	-	-	-	-	-
16- 18	-	-	-	-	-	-	-	-	-	-	-	-	-
19- 21	1	-	-	-	-	-	-	-	-	-	-	-	-
22- 24	15	-	-	-	-	-	-	-	2	-	-	-	1
25- 27	11	-	-	-	-	-	-	-	-	-	-	-	5
28- 30	14	-	-	-	-	-	-	-	2	-	-	-	4
31- 33	11	-	-	3	-	-	-	-	4	-	-	-	4
34- 36	18	2	-	1	-	-	-	-	10	-	-	-	5
37- 39	18	-	-	2	-	-	-	-	4	-	-	-	12
40- 42	11	2	-	-	-	-	-	-	2	-	1	-	6
43- 45	8	-	2	-	-	-	-	-	1	-	1	-	13
46- 48	8	3	-	-	-	-	-	-	8	1	1	-	8
49- 51	17	-	-	-	-	-	-	-	5	-	3	-	9
52- 54	15	-	-	-	1	-	-	-	-	-	-	1	2
55- 57	8	-	2	1	-	-	-	-	10	-	1	-	-
58- 60	3	1	-	-	-	-	1	-	4	-	1	-	-
61- 63	5	1	1	-	1	-	2	-	-	-	-	-	-
64- 66	3	-	-	-	-	-	-	-	-	-	-	1	-
67- 69	-	-	-	-	-	-	1	-	1	1	2	-	1
70- 72	-	1	-	-	-	-	3	-	-	-	-	1	-
73- 75	-	-	-	-	-	1	1	-	-	-	1	1	-
76- 78	-	-	-	-	-	-	-	1	-	-	-	-	-
79- 81	-	-	1	-	-	-	1	-	-	-	-	-	-
82- 84	-	-	-	-	-	-	2	-	-	-	-	-	-
85- 87	-	-	-	-	-	-	2	1	-	-	-	-	-
88- 90	-	-	-	-	-	-	1	1	-	-	1	-	-
91- 93	-	1	-	-	-	-	2	-	-	-	1	-	-
94- 96	-	-	-	-	-	-	-	1	-	-	-	-	-
97- 99	-	1	-	-	-	-	1	-	-	-	1	-	-
100-102	-	-	1	-	-	-	1	1	-	-	3	2	-
103-105	1	-	-	-	-	-	-	1	-	-	-	-	-
106-108	-	1	-	-	-	-	-	-	-	-	-	-	1
109-111	-	-	-	-	-	-	-	-	-	-	-	1	-
112-114	-	-	-	-	-	-	-	1	-	-	-	1	-
115-117	-	-	-	-	-	-	-	1	-	-	-	1	-
118-120	-	-	-	-	-	-	-	-	-	-	-	-	-
121-123	-	-	-	-	-	-	1	-	-	-	-	-	-
124-126	-	-	-	-	-	-	-	-	-	-	-	-	-
127-129	-	-	-	-	-	-	-	-	-	-	-	-	-
130-132	-	-	-	-	-	-	-	-	-	-	-	-	-
133-135	-	-	-	-	-	-	-	-	-	-	-	-	-
136-138	-	1	-	-	1	-	-	-	-	-	-	-	-
139-141	-	-	-	-	-	-	-	1	-	-	-	-	-
142-144	-	-	-	-	-	-	-	-	-	-	-	-	-
145-147	-	-	-	-	-	-	1	-	-	-	-	-	-
148-150	-	-	-	-	-	-	-	-	-	-	-	-	-
151-153	-	-	-	-	-	-	-	-	-	-	-	-	-
154-156	-	-	-	-	-	-	-	-	-	-	-	-	-
157-159	-	-	-	-	-	-	*	-	-	-	†	-	-

Mm.	14. 1899—11th Aug. 2 h 30 m.	15. 1899—30th Oct. 2 h. 30 m.	16. 1900—27th July. 2 h. 30 m.	17. 1900—10th Sept. 2 h. 0 m.	1 1900—11th Dec. 2 h. 0 m.	19. 1901—4th July. 2 h. 30 m.	20. 1901—30th Aug. 2 h. 0 m.	21. 1903—24th June. 2 h. 0 m.	22. 1903—13th July. 2 h. 40 m.	23. 1903—26th Aug. 2 h. 30 m.	24. 1903—24th Sept. 2 h. 30 m.	25. 1904—1st July. 2 h. 0 m.
10- 12	46 not measured.	-	-	-	-	-	-	-	-	-	-	-
13- 15		-	-	-	-	-	-	5	-	-	-	-
16- 18		-	-	-	-	5	-	34	-	-	-	1
19- 21		-	-	-	-	26	-	27	7	-	-	2
22- 24		-	-	-	-	93	-	16	15	-	-	3
25- 27		-	-	-	-	130	-	10	11	-	-	3
28- 30		-	2	-	-	138	-	1	8	-	-	4
31- 33		-	2	-	-	75	-	-	1	-	-	2
34- 36		-	9	-	-	34	5	-	1	3	-	2
37- 39		-	12	-	-	20	13	-	2	6	-	1
40- 42		-	9	-	-	11	14	-	-	11	-	1
43- 45		-	14	8	-	3	10	-	1	8	-	1
46- 48		-	15	6	3	3	6	-	2	4	2	-
49- 51		-	12	4	2	1	4	-	-	2	2	-
52- 54		-	6	8	3	-	1	-	-	2	4	-
55- 57		-	5	9	3	-	1	-	1	2	2	-
58- 60		-	3	3	2	-	3	-	-	1	1	-
61- 63		-	6	4	1	-	2	-	-	1	2	-
64- 66		2	5	4	5	-	-	-	-	1	1	-
67- 69		1	3	2	2	-	4	-	-	-	3	-
70- 72		1	1	3	-	-	-	-	-	-	1	-
73- 75		2	-	-	-	-	6	-	-	-	1	-
76- 78		1	1	2	-	-	2	-	-	1	-	-
79- 81		1	1	6	-	-	2	-	-	1	1	-
82- 84		-	-	4	1	-	3	-	-	-	-	-
85- 87		-	-	3	1	-	2	-	-	-	-	-
88- 90		-	-	2	-	-	1	-	-	-	1	-
91- 93		-	-	2	-	-	-	-	-	-	2	-
94- 96		3	-	-	-	-	-	-	-	-	1	-
97- 99		-	-	1	-	-	-	-	-	-	-	-
100-102		-	-	-	-	-	-	-	-	-	-	-
103-105		1	-	-	-	-	-	-	-	-	-	-
106-108		-	-	-	-	-	-	-	-	-	-	-
109-111		-	-	-	-	-	-	-	-	-	-	-
112-114		-	-	-	-	-	-	-	-	-	-	-
115-117		1	-	-	-	-	-	-	-	-	-	-
118-120		-	-	-	-	-	-	-	-	-	-	-
121-123		-	-	-	-	-	-	-	-	-	-	-
124-126		-	-	-	-	-	-	-	-	-	-	-
127-129		-	-	-	-	-	-	-	-	-	-	-
130-132		-	-	-	-	-	-	-	-	-	-	-
133-135		-	-	-	-	-	-	-	-	-	-	-
136-138		-	-	-	-	-	-	-	-	-	-	-
139-141		-	-	-	-	-	-	-	-	-	-	-
142-144		-	-	-	-	-	-	-	-	1	-	1
145-147		-	-	-	-	-	-	-	-	-	-	-
148-150		-	-	-	-	-	-	-	-	-	-	-
151-153		-	-	-	-	-	-	-	-	-	-	-
154-156		-	-	-	-	-	-	-	-	-	-	-
157-159		-	-	-	‡	-	-	-	-	-	-	-

Mm.	26. 1904—1st Aug. 2 h. 15 m.	27. 1904—25th Aug. 1 h. 30 m.	28. 1905—7th July. 2 h. 0 m.	29. 1905—19th Aug. 2 h. 0 m.	30. 1905—18th Sept. 2 h. 0 m.	31. 1906—26th June. 2 h. 0 m.	32. 1906—26th July. 2 h. 15 m.	33. 1906—24th Aug 2 h. 0 m.	34. 1907—28th June. 2 h. 15 m.	35. 1908—16th June. 1 h. 50 m.	36. 1908—17th July. 2 h. 0 m	37. 1908—13th Aug. 2 h. 10 m.
10- 12	-	-	-	-	-	-	-	-	-	-	-	-
13- 15	-	-	1	-	-	-	-	-	-	1	-	-
16- 18	-	-	5	-	-	-	-	-	-	-	-	-
19- 21	-	-	23	-	-	-	-	-	-	-	-	-
22- 24	-	-	23	-	-	-	1	-	-	5	-	1
25- 27	-	-	21	-	-	-	-	-	-	29	-	-
28- 30	-	-	42	4	-	-	-	-	-	27	-	-
31- 33	-	-	31	10	-	4	3	1	3	28	2	3
34- 36	1	-	15	14	-	-	3	6	7	16	3	3
37- 39	3	-	12	17	3	-	1	9	10	4	4	4
40- 42	4	-	8	34	3	-	2	5	11	2	7	2
43- 45	1	2	5	21	3	-	-	2	11	1	6	-
46- 48	4	1	2	13	5	-	-	2	6	-	-	1
49- 51	3	-	3	7	7	-	1	5	6	-	2	1
52- 54	1	-	3	5	6	-	1	5	1	-	2	3
55- 57	1	-	4	1	-	-	2	2	1	-	2	3
58- 60	3	-	3	-	4	-	-	2	1	-	-	2
61- 63	1	-	4	2	3	-	1	5	-	-	1	2
64- 66	-	-	3	-	-	-	1	2	-	-	-	2
67- 69	-	1	1	-	1	-	1	2	-	-	-	1
70- 72	-	-	-	-	-	-	1	-	-	-	-	2
73- 75	-	-	-	-	-	-	-	-	-	-	-	1
76- 78	-	1	-	-	1	-	-	1	-	-	1	-
79- 81	-	-	-	-	-	-	-	4	-	-	-	1
82- 84	-	-	-	1	-	-	-	-	-	-	-	-
85- 87	-	-	-	-	1	-	-	1	-	-	-	-
88- 90	-	-	-	-	-	-	-	-	-	-	-	-
91- 93	-	-	-	-	-	-	-	-	-	-	-	-
94- 96	-	-	-	-	-	-	-	-	-	-	-	-
97- 99	-	-	-	-	-	-	-	-	-	-	-	-
100-102	-	-	-	-	-	-	-	-	-	-	-	-
103-105	-	-	-	-	-	-	-	-	-	-	-	-
106-108	-	-	-	-	-	-	-	-	-	-	-	-
109-111	-	-	-	-	-	-	-	-	-	-	-	-
112-114	-	-	-	-	-	-	-	-	-	-	-	-
115-117	-	-	-	-	-	-	-	-	-	-	-	-
118-120	-	-	-	-	-	-	-	-	-	-	-	-
121-123	-	-	-	-	-	-	-	-	-	-	-	-
124-126	-	-	-	-	-	-	-	-	-	-	-	-
127-129	-	-	-	-	-	-	-	-	-	-	-	-
130-132	-	-	-	-	-	-	-	-	-	-	-	-
133-135	-	-	-	-	-	-	-	-	-	-	-	-
136-138	-	-	-	-	-	-	-	-	-	-	-	-
139-141	-	-	-	-	-	-	-	-	-	-	-	-
142-144	-	-	-	-	-	-	-	-	-	-	1	-
145-147	-	-	-	-	-	-	-	-	-	-	-	-
148-150	-	-	-	-	-	-	-	-	-	-	-	-
151-153	-	-	-	-	-	-	-	-	-	-	-	-
154-156	-	-	-	-	-	-	-	-	-	-	-	-
157-159	-	-	-	-	-	-	-	-	-	-	-	-

* One 169, one 170, one 176. † One 180. ‡ One 177; one 202.

TABLE IV. (*continued*)—V. INVERARAY.

Mm.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.	32.	33.	34.	35.	36.	37.	38.	39.
	1896—14th July. 2 h. 0 m.	1896—11th Nov. 2 h. 0 m.	1897—27th Mar. 2 h. 0 m.	1897—28th July. 0 h 30 m.	1897—6th Oct. 0 h. 30 m.	1897—27th Nov. 2 h. 30 m.	1898—18th Feb. 0 h. 30 m.	1898—21st Feb. 2 h. 0 m.	1898—18th April. 2 h. 30 m.	1898—7th July. 2 h. 30 m.	1898—21st Sept. 0 h. 30 m.	1899—8th Jan. 2 h. 0 m.	1899—22nd Apl. 2 h. 30 m.	1899—22nd June. 2 h. 30 m.	1899—17th Aug. 2 h. 30 m.	1899—24th Oct. 2 h. 30 m.	1900—23rd Apl. 2 h. 30 m.	1900—28th July. 2 h. 30 m.	1900—10th Sept. 2 h. 30 m.	1900—11th Dec. 2 h. 0 m.	1901—27th Mar. 2 h. 0 m.	1901—10th Apl. 2 h. 0 m.	1901—4th July. 2 h. 30 m.	1901—31st Aug. 2 h. 30 m.	1903—22nd June. 2 h. 0 m.	1903—10th July. 3 h. 30 m.	1903—20th Aug. 2 h. 30 m.	1903—23rd Sept. 2 h. 0 m.	1904—30th June. 2 h. 0 m.	1904—2nd Aug. 2 h. 30 m.	1904—19th Aug. 2 h. 30 m.	1905—7th July. 2 h. 5 m.	1905—19th Aug. 1 h. 15 m.	1905—19th Sept. 2 h. 0 m.	1906—25th June. 2 h. 0 m.	1906—25th July. 2 h. 0 m.	1906—23rd Aug. 2 h. 0 m.	1908—16th July. 2 h. 0 m.	1908—12th Aug. 2 h. 10 m.
10- 12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5 plaice not measured.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13- 15	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16- 18	-	-	-	-	-	-	-	-	-	-	-	-	-	1		-	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-	1	-	-	-	-	-	-	-
19- 21	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	1	-	10	5	-	-	2	-	-	1	-	-	-	-	-	-	-
22- 24	-	-	-	-	-	-	-	-	-	-	-	-	-	3		-	-	-	-	-	-	-	5	-	18	15	-	-	2	-	-	8	-	-	-	-	-	-	-
25- 27	4	-	-	-	-	-	-	-	-	1	-	-	-	1		-	-	-	-	-	-	-	20	-	12	22	-	-	-	-	-	8	-	-	1	-	-	-	1
28- 30	16	-	-	-	-	-	-	-	-	9	-	-	-	3		-	-	1	-	-	-	-	113	-	18	16	-	-	-	-	-	5	-	-	-	-	-	-	-
31- 33	21	1	-	-	-	-	-	-	-	16	-	-	-	3		-	-	-	-	-	-	-	200	-	15	23	-	-	-	2	1	18	1	-	1	-	-	1	-
34- 36	15	2	-	1	-	-	-	-	-	37	-	-	-	15		-	-	1	-	-	-	-	191	-	5	12	-	-	-	1	-	21	4	-	1	-	-	-	-
37- 39	14	7	-	-	-	-	-	-	-	30	-	-	-	13		-	-	1	-	-	-	-	153	-	1	3	1	-	-	2	3	29	11	-	-	-	-	-	-
40- 42	11	5	1	-	-	-	-	-	-	45	-	-	-	12		-	-	1	-	-	-	-	91	-	1	2	2	-	-	2	1	19	14	-	-	-	-	2	-
43- 45	13	2	2	1	-	-	-	-	-	34	-	-	-	4		-	-	5	-	-	-	-	60	-	2	1	1	-	-	2	-	34	14	2	-	-	-	2	1
46- 48	8	2	2	2	-	-	-	-	-	46	-	-	-	1		-	-	3	-	-	-	-	31	1	1	2	2	-	-	1	2	12	6	1	-	1	-	1	-
49- 51	9	-	3	-	-	-	-	-	-	73	-	-	-	2		-	-	8	-	-	-	-	20	1	-	1	6	1	-	4	-	16	5	3	-	-	-	4	1
52- 54	7	-	-	1	-	-	-	-	-	47	-	-	-	-		1	-	15	2	-	-	-	9	-	-	-	4	2	-	1	-	6	1	1	-	1	-	3	1
55- 57	8	-	4	1	-	-	-	1	-	17	4	-	-	-		-	-	14	3	-	-	-	5	7	-	-	2	4	-	2	2	1	-	5	-	-	-	2	1
58- 60	10	-	1	-	-	3	-	1	-	12	5	-	-	-		-	-	9	2	-	-	-	1	13	-	-	7	3	-	2	1	3	-	4	-	-	-	2	3
61- 63	8	-	-	4	-	1	-	2	-	5	4	-	-	-		-	-	5	3	-	-	-	-	28	-	-	7	2	-	1	-	3	-	3	-	-	-	1	-
64- 66	5	-	-	-	2	2	-	1	-	2	3	-	-	-		-	-	2	5	-	-	-	-	21	-	-	6	1	-	-	-	3	-	-	-	-	-	1	-
67- 69	1	-	-	-	-	4	-	-	-	-	4	1	-	-		-	-	2	5	-	-	-	-	19	-	-	1	2	-	-	-	-	-	1	-	1	1	1	-
70- 72	-	-	-	-	-	2	1	1	-	-	3	-	-	-		-	-	2	7	-	-	-	-	18	-	-	1	2	-	1	-	1	-	1	-	-	-	-	-
73- 75	-	-	-	-	1	2	-	2	1	-	1	-	1	-		1	-	-	2	-	-	-	-	10	-	-	2	-	-	-	-	-	-	2	-	-	-	-	1
76- 78	-	-	-	-	-	-	-	-	-	-	2	1	-	-		-	-	2	5	-	1	-	-	5	-	-	2	2	-	-	-	-	1	2	-	-	-	-	1
79- 81	-	1	1	1	1	1	-	-	-	-	2	-	-	-		1	-	-	-	-	-	-	-	6	-	-	1	2	-	-	-	-	-	1	-	-	-	-	2
82- 84	-	-	-	-	-	2	-	-	1	-	-	-	-	-		-	-	-	-	-	1	-	-	2	-	-	3	1	-	-	1	-	-	-	-	-	-	-	1
85- 87	-	-	1	-	-	1	-	1	1	-	1	1	-	-		-	-	-	-	-	-	-	-	2	-	-	1	-	-	-	-	-	-	1	-	-	1	-	-
88- 90	-	-	-	3	-	1	1	-	-	-	-	1	1	-		1	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	3
91- 93	-	-	-	-	-	1	1	-	-	-	2	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	1	-	-	-	-	1
94- 96	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
97- 99	-	-	-	-	-	-	-	-	1	-	-	-	-	-		1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
100-102	-	-	-	-	-	1	1	-	-	-	-	-	2	-		3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
103-105	-	-	-	-	-	2	-	-	-	-	1	-	-	-		-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
106-108	-	-	-	-	-	-	-	-	-	-	-	-	-	-		1	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
109-111	-	-	-	-	-	-	-	-	-	-	-	-	-	-		1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
112-114	-	-	-	-	-	-	-	1	1	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
115-117	-	-	-	-	-	-	-	-	2	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
118-120	-	-	-	-	-	-	-	-	-	-	-	-	1	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
121-123	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
124-126	-	-	-	-	-	-	-	-	1	-	-	-	-	-		-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
127-129	-	-	-	-	-	-	-	-	-	-	-	-	-	1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
130-132	-	-	-	-	-	-	-	-	1	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
133-135	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
136-138	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
139-141	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
142-144	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
145-147	-	-	-	-	-	-	1	-	1	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
148-150	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
151-153	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
154-156	-	-	-	-	-	-	1	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
157-159	-	-	-	-	-	-	*	-	-	-	-	-	-	-		-	-	-	-	†	-	‡	-	-	-	-	-	-	-	-	-	-	-	-	-	-	§	-	‖

* One 182. † One 194. ‡ One 190. § One 198. ‖ One 162.

TABLE V.—Showing the Temperatures, Densities, and Weather Conditions at the Stations.

I. LOCHGILPHEAD.

Date.	Temp. °F. Air.	Temp. °F. Water	Density.	Wind.	Weather.	Sea.	Bottom.
Nov. 18, 1897	—	48·3	—	—	—	—	—
Oct. 11, ,,	—	50·3	—	—	—	—	—
Feb. 15, 1898	—	45·1	—	—	—	—	—
April 22, ,,	—	49·6	—	—	—	smooth, clear	—
July 1, ,,	—	54·7	—	—	—	clear	—
Sept. 20, ,,	—	56·9	—	—	—	dull	—
Dec. 19, ,,	—	47·1	—	—	snow showers, overcast	clear	—
April 25, 1899	—	48·6	—	N.W. 4	heavy rain	smooth	—
Aug. 10, ,,	—	59·7	—	N.E. 2	—	clear, smooth	—
Oct. 23, ,,	—	50·4	—	S.W. 2	cloudy	smooth	—
April 18, 1900	—	47·5	—	—	overcast	calm, clear	—
July 26, ,,	—	56·1	—	N.W. 3	cloudy	smooth, clear	—
Sept. 12, ,,	53·8	53·4	26·0	N.W. ½	clear	smooth, clear	some weeds
July 2, 1901	—	58·6	25·4	calm	clear	smooth, clear	weedy
July 30, 1904	61·5	61·0	23·6	S.E., mod.	cloudy, fine	brownish	—
Aug. 18, ,,	59·7	58·6	22·8	S.W., very light	fine bright sun	clear, smooth	very weedy
July 5, 1905	—	56·5	25·8	S.W., light	dull, rain	clear, smooth	weedy
Aug. 15, ,,	—	57·2	25·2	S.E., mod.	very dull, rain	rough nr. shore	weedy
Sept. 16, ,,	—	52·3	26·0	N.W., mod.	dull, showery	clear, smooth	clean
June 22, 1906	60·8	59·7	24·0	S.W., light	—	quite clear	weedy
July 23, ,,	58·8	56·5	24·3	S.W.	dull, showery	fairly clear	few weeds
Aug. 21, ,,	59·0	57·2	26·0	S.W., light	—	very brown	—
July 1, 1907	52·5	51·1	25·6	N.W.	—	dark	weedy
June 13, 1908	49·3	46·4	25·6	S.E.	heavy rain	dirty	few weeds
July 13, ,,	68·0	60·8	26·0	S.W.	showers	clear	weedy
Aug. 14, ,,	46·4	44·6	26·0	N.W.	—	clear	few weeds

II. BIG HARBOUR.

Date.	Temp. °F. Air.	Temp. °F. Water	Density.	Wind.	Weather.	Sea.	Bottom.
Oct. 12, 1897	—	50·9	—	—	—	—	—
Nov. 20, ,,	—	50·5	—	—	—	—	—
Feb. 25, 1898	—	44·6	—	—	—	—	—
March 1, ,,	—	44·2	—	—	—	clear	—
April 15, ,,	—	50·2	—	—	—	very clear	—
April 20, ,,	—	47·2	—	—	—	nice and dull	—
June 29, ,,	—	56·5	—	—	—	clear	—
Sept. 29, ,,	—	52·2	—	S.E., strong	heavy rain	thick	—
Dec. 20, ,,	—	45·5	—	—	showers	quite clear	—
Jan. 11, 1899	—	44·9	—	—	rain and sleet	clear	—
April 14, ,,	—	44·6	—	E., strong	cloudy	clear, smooth	—
June 23, ,,	—	54·7	—	—	cloudy, rain	clear	—
Aug. 10, ,,	—	56·8	—	calm	—	very clear, smooth	—
Oct. 17, ,,	—	—	—	S. 4	—	dull	—
July 26, 1900	—	55·4	—	W.N.W. 1	cloudy, showers	clear, smooth	—
Sept. 11, ,,	61·2	55·2	25·8	N.W. 1	dull	clear, smooth	good
July 3, 1901	—	58·3	24·9	calm	clear	clear, smooth	—
Aug. 29, ,,	—	57·7	25·3	N.W., light	dull, rain	clear	—
June 25, 1903	55·4	54·9	—	calm	—	clear, smooth	—
July 13, ,,	57·2	55·2	—	—	—	smooth	—
Aug. 25, ,,	55·0	54·7	—	—	cloudy	clear, smooth	—
Sept. 25, ,,	55·4	55·0	25·2	—	dull	clear, smooth	—
June 28, 1904	58·3	57·6	25·3	S.E., mod.	bright sun	clear, smooth	weedy
July 28, ,,	61·2	59·4	24·1	S., very light	fine, sunny	clear, smooth	clean
Aug. 17, ,,	61·5	59·5	25·0	S., gentle	fine	clear, smooth	clean
July 6, 1905	—	55·0	26·2	N., mod.	dull	very clear	clean
Aug. 15, ,,	—	59·0	25·8	—	dull	clear, smooth	clean
Sept. 15, ,,	—	52·2	25·9	S.W., mod.	dull, rain	clear, rough	clean
June 23, 1906	58·6	52·7	26·5	S.W., light	—	clear, smooth	very weedy
July 24, ,,	58·3	56·5	22·0	S.W.	—	clear	very weedy
Aug. 21, ,,	57·2	57·2	24·0	W., light	—	dark	—
June 27, 1907	50·0	48·2	20·0	W.	showery	clear	—
June 13, 1908	51·8	49·6	26·0	S.E., strong	raining	very clear	very weedy
July 15, ,,	60·6	59·4	25·6	S.E.	showery	dark	—
Aug. 11, ,,	57·7	54·0	26·8	N.N.W.	—	clear	weedy

III. Salen Bay.

Date.			Temp. °F. Air.	Water	Density.	Wind.	Weather.	Sea.	Bottom.
July	10,	1896	—	—	—	—	—	very clear	clean
Nov.	21,	1897	—	49·8	—	—	—	—	—
Feb.	28,	1898	—	—	—	—	—	clear	—
April	14,	,,	—	46·4	—	—	—	rough, dull	—
June	28,	,,	—	56·8	—	—	—	very clear	—
Sept.	30,	,,	—	53·2	—	northerly, light	cloudy, rain	thick, muddy	—
Dec.	22,	,,	—	45·5	—	S.W. breeze	—	—	—
Jan.	11,	1899	—	43·8	—	—	cloudy, showers	calm	—
April	19,	,,	—	43·5	—	N. 3	clear, sunny	clear	—
June	20,	,,	—	51·2	—	—	dull, rain	clear	weedy
Aug.	9,	,,	—	55·4	—	S.E. 2	—	very clear, smooth	—
Oct.	31,	,,	—	—	—	W.S.W. 4	overcast	choppy, dull	—
April	18,	1900	—	46·0	—	W. 4	rain	dull, smooth	—
July	25,	,,	—	56·8	—	N. 3	rain	clear, smooth	—
Sept.	13,	,,	49·1	51·3	26·2	calm	clear	clear, smooth	good
July	2,	1901	—	52·9	25·4	—	calm	clear, smooth	—
Aug.	29,	,,	—	57·7	25·4	N.W., med.	favourable	clear	—
Sept.	25,	1903	54·1	54·0	25·0	—	very dull	dirty, choppy	weedy
June	29,	1904	56·5	54·3	25·2	S., very li t	fine, sunny	clear, calm	clean
July	29,	,,	60·8	60·4	25·0	S.E., light	very dull, rain	clear, rough	clean
Aug.	16,	,,	59·5	58·8	25·3	W., lig t	fine, cloudy	clear, smooth	little weedy
July	4,	1905	—	55·4	26·2	S.W., light	dull, rain	clear, smooth	weedy
Aug.	16,	,,	—	57·0	25·7	calm	dull	clear, smooth	clean
Sept.	14,	,,	—	52·2	26·2	S., light	dull	very clear	dirty
June	22,	1906	61·9	56·7	22·5	calm	—	clear, smooth	weedy
July	24,	,,	56·5	53·6	22·8	S.W., light	showery	dark	weedy
Aug.	22,	,,	60·1	55·4	23·6	S.E.	—	very dark	—
June	27,	1907	49·6	47·8	22·8	W.	—	dark	very weedy
June	15,	1908	51·8	48·2	25·8	S.W., strong	—	muddy	very weedy
July	15,	,,	64·4	59·0	26·8	W.	—	dark	very weedy
Aug.	11,	,,	57·9	54·0	26·8	N.N.W.	—	clear	weedy

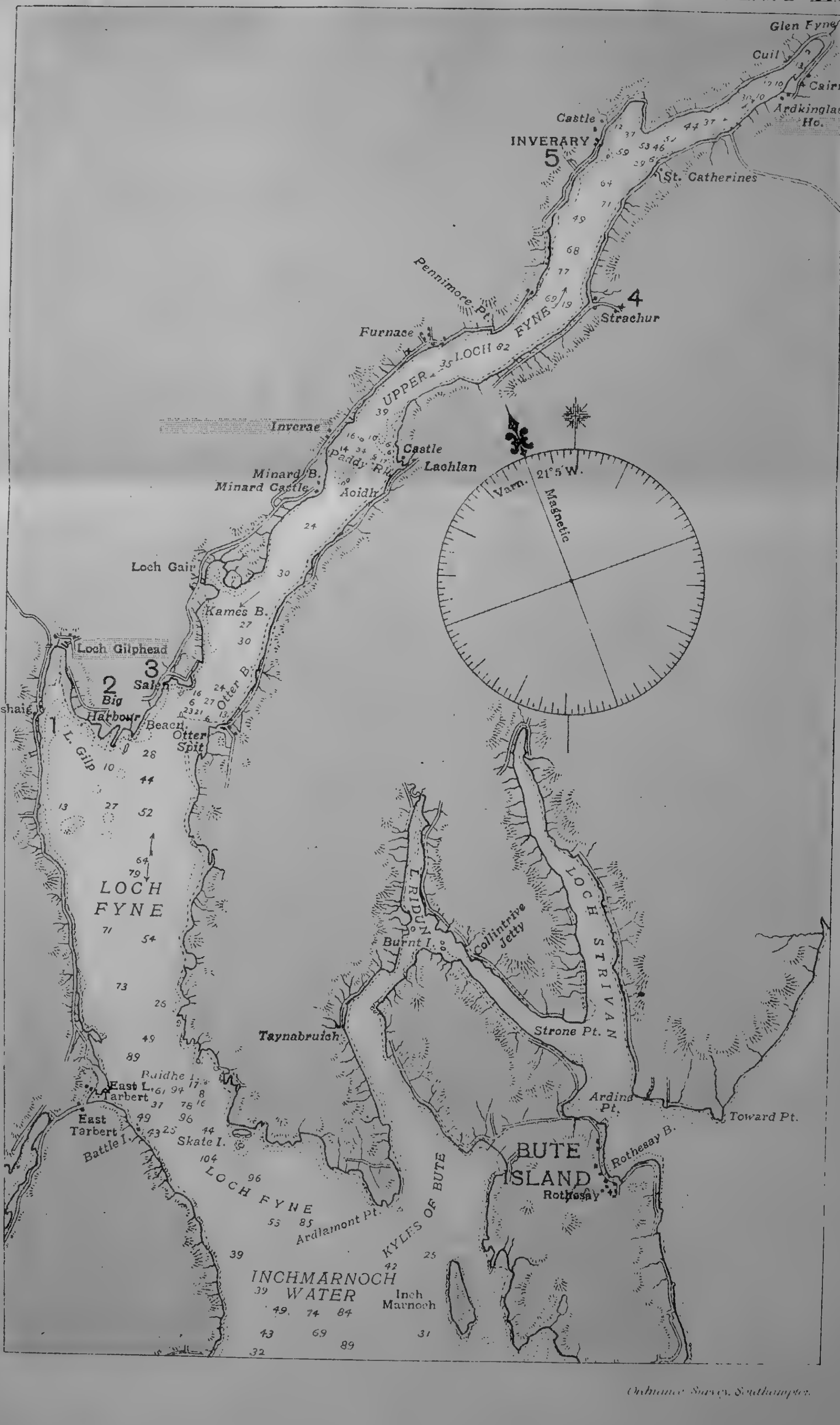
IV. Strachur.

Date.			Air.	Water	Density.	Wind.	Weather.	Sea.	Bottom.
July	14,	1896	—	—	—	—	—	clear	—
Oct.	8,	1897	—	51·8	—	—	—	—	—
Nov.	22,	,,	—	49·2	—	—	—	—	—
Feb.	23,	1898	—	42·8	—	—	—	dull	—
April	19,	,,	—	49·8	—	—	—	very clear	—
July	12,	,,	—	58·8	—	—	—	rough on beach	—
Sept.	23,	,,	—	57·2	—	—	—	quite clear	—
Jan.	10,	1899	—	45·6	—	—	calm, fine	little dirty	—
April	24,	,,	—	46·6	—	S.E., light	heavy rain	clear, smooth	—
June	21,	,,	—	56·4	—	—	cloudy	clear, smooth	—
Aug.	11,	,,	—	58·3	—	S.W. 1	bright sun	clear, smooth	—
Oct.	30,	,,	—	47·8	—	W.S.W. 7	overcast	dull	weedy
July	27,	1900	—	55·8	—	calm	sunshine	clear, smooth	—
Sept.	10,	,,	59·0	56·5	22·6	N.W. 4	overcast	clear, choppy	very weedy
July	4,	1901	—	54·1	24·9	—	misty	smooth	—
Aug.	30,	,,	—	57·7	22·2	against shore	rainy	dull	—
July	13,	1903	—	55·6	—	—	dull	smooth	—
Aug.	26,	,,	54·7	54·0	—	—	rainy	clear, smooth	—
Sept.	24,	,,	56·1	55·2	23·0	light	very dull	clear, smooth	—
July	1,	1904	55·2	55·8	26·0	S. strong breeze	rain and very dull	clear	clean
Aug.	1,	,,	60·1	59·0	25·8	S.W., mod.	dull, rain	clear, smooth	very clean
Aug.	20,	,,	57·7	55·4	23·6	N.W., light	fine, sunny	very clear	weedy
July	7,	1905	—	57·2	26·1	W., mod.	dull	clear	clean
Aug.	18,	,,	—	55·2	25·2	W., strong	dull, rain	rough nr. shore	muddy
Sept.	18,	,,	—	55·6	15·6	calm	very dull	clear, smooth	weedy
June	26,	1906	56·5	57·6	24·0	W.	showery	dark, choppy	weedy
July	26,	,,	72·3	63·0	20·6	S.S.E.	—	little muddy	slight weeds
Aug.	24,	,,	58·3	57·2	22·6	none	—	dark	weedy
June	28,	1907	50·7	48·6	23·0	N.W.	—	clear	weedy
June	16,	1908	50·0	46·8	25·0	S.	showers	clear	weedy
July	17,	,,	61·9	57·2	27·0	S.W.	—	clear	weedy
Aug.	13,	,,	60·0	53·6	26·8	W.	—	dark	little weeds

V. Inveraray.

Date.	Temp. °F.		Density.	Wind.	Weather.	Sea.	Bottom.
	Air.	Water					
July 14, 1896	—	—	—	—	—	clear	—
Nov. 27, 1897	—	42·2	—	—	—	—	—
Feb. 18, 1898	—	41·5	—	—	—	dull	—
Feb. 21, ,,	—	41·0	—	—	—	—	—
April 18, ,,	—	48·8	—	—	—	very clear	—
July 7, ,,	—	56·3	—	—	—	smooth, thick	—
Sept. 21, ,,	—	56·5	—	—	—	thick, muddy	—
Jan. 8, 1899	—	42·4	—	—	—	clear, calm	—
April 22, ,,	—	46·8	—	W. 2	cloudy	dull, smooth	—
June 22, ,,	—	54·7	—	—	showery	dull	—
Aug. 17, ,,	—	61·9	—	W. 7	bright sun	clear, smooth	—
Oct. 24, ,,	—	50·0	—	calm	overcast	smooth	weedy
April 23, 1900	—	52·9	—	S.W. 1	cloudy	very clear	—
July 28, ,,	—	56·2	—	N.E. 3	dull, cloudy	dull, choppy	—
Sept. 10, ,,	56·3	55·6	22·2	N.W. 0·2	dull, rainy	clear, smooth	good
Mar. 27, 1901	—	46·2	26·9	W.	heavy rain	dull	—
April 10, ,,	—	41·7	11·5	calm	sunny	clear	clean
July 4, ,,	—	58·8	24·9	calm	dull	yellow-brown	fairly clean
Aug. 31, ,,	—	56·3	8·4	light	heavy rain	smooth	—
July 10, 1903	55·2	55·8	—	—	heavy rain	clear, smooth	—
Aug. 25, ,,	55·6	54·3	—	—	rainy	clear, smooth	—
Sept. 23, ,,	57·4	56·7	21·2	light	dull, rain	clear, smooth	—
June 30, 1904	55·4	56·5	25·6	S., strong	showery	brownish	clean
Aug. 2, ,,	60·8	60·4	26·1	S.W., gentle	dull, rain	clear, smooth	clean
Aug. 19, ,,	60·8	60·1	24·2	calm	fine, cloudy	clear, smooth	muddy
July 7, 1905	—	57·7	25·9	W., mod.	dull	clear, smooth	clean
Aug. 19, ,,	—	54·7	25·0	N.W., strong	dull, rain	rough near shore	dirty, weedy
Sept. 19, ,,	—	53·6	22·8	S., light	dull, rain	clear, smooth	mud and leaves
June 25, 1906	56·1	56·8	25·5	W.	rain, thunder	broken	—
July 25, ,,	65·8	57·2	10·4	S.S.W.	light showers	clear	weedy
Aug. 23, ,,	58·3	55·8	22·0	S.S.E.	—	brown	—
June 15, 1908	50·0	47·1	23·2	S., very strong	heavy rain	dark, choppy	very weedy
July 16, ,,	68·0	60·8	23·6	S.W.	rain	clear	weedy
Aug. 12, ,,	59·0	50·7	25·2	W.	rain	clear	very weedy

PLATE II.



Ordnance Survey, Southampton.

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III.—SOME NOTES ON FISH PARASITES.

By Thomas Scott, LL.D., F.L.S.

(Plates III.-VII.)

Papers containing records and descriptions of parasites more or less peculiar to fishes have been contributed at various times to Part III. of the Annual Reports published during previous years by the Fishery Board for Scotland. In the present paper there are notes on several additional species, some of which are interesting because of their strange and unusual forms.

These notes have been prepared from specimens obtained at various times chiefly in connection with research work undertaken on behalf of the Board, but a few have reached me from other sources. Some of the specimens have been in my possession for several years, while others have only recently been obtained.

I am indebted to my colleague, Dr. Williamson, for some of the species recorded, and to my son, Andrew Scott, A.L.S., for the drawings and photographs with which the paper is illustrated.

The species to be described comprise examples both of the Ectoparasites and the Endoparasites of fishes. Three species belonging to the former group appear to be new to science, while some rare and curious forms are included among those belonging to the second group.

The various species mentioned in the sequel are arranged and described in the following order:—

(1) Ectozoa.

CRUSTACEA.

Copepoda.

Pandarus bicolor, *Leach*, var.
Hatschekia cornigera, sp. n.
Chondracanthus Williamsoni, sp. n.

PLATYHELMINTHA.

Trematoda-ectoparasitica.

Octobothrium Sybillæ, sp. n.

(2) Entozoa.

Trematoda Endoparasitica.

Distoma cestoides, Ed. van Beneden.

Cestoda.

Bothriocephalus proboscideus, Rudolphi.
" *punctatus* (Rudolphi).
Ancistrocephalus microcephalus (Rudolphi).

Schistocephalus solidus, Creplin.
Tetrarhynchus minutus, P. J. van Beneden
,, *tetrabothrius*, P. J. van Beneden.
,, *megacephalus*, Rudolphi.
Phyllobothrium thridax, P. J. van Beneden.
,, *lactuca*, P. J. van Beneden.
Acanthobothrium coronatum, P. J. van Beneden.
Dinobothrium septaria, P. J. van Beneden.
Diplobothrium simile, P. J. van Beneden.
Abothrium rugosum, Goeze.
Taenia sp.

NEMATHELMINTHA

Acanthocephala.

Echinorhynchus proteas, Westrumb.
,, *acus*, Rudolphi.
,, ,, ? var.
,, *agilis*, Rudolphi.

ADDITIONAL NOTES.

(1) On a large Cestode from the intestines of a Common Porpoise.
(2) On Nematodes observed in the viscera of a Common Porpoise.
(3) On the injurious effects of parasites on fishes.

The following are descriptions of the various species mentioned above:—

CRUSTACEA.

Copepoda-Caligoida.

Genus *Pandarus*, Leach (1816).

In a previous paper* I gave a description and figures of *Pandarus bicolor*, Leach. These specimens had been obtained from the Tope, *Galeus canis*, Rondel. I have now to record the same kind of parasite from the Picked Dog-fish, *Squalus acanthias*, Linn. A considerable number of these fishes, captured off the West of Scotland and landed at the Fish Market at Aberdeen in March of this year (1908), were examined at the Laboratory at the Bay of Nigg. On these Dog-fishes quite a number of *Pandarus bicolor* were observed; they resembled those previously described in form and colour. Figure 19, Plate III., represents one of the specimens. The cephalon is ornamented by deep chocolate-brown pigment, as shown in the drawing; the middle plates are also coloured, but not so deeply. The body seen from above is elongated and somewhat eliptical in outline, but flat when seen from the side. Among the specimens of normal form and colour was one that differed from the others in both characters, but especially in colour. This specimen is represented by figure 18 on the same plate. This form resembles in some respects a species described in 1888 by Lay under the name of *Pandarus sinuatus*, and to that species I was at first inclined to ascribe it. Probably, however, it

**Eighteenth Annual Report of the Fishery Board for Scotland*, Part III., p. 157, Pl. VI., figs. 33–38 (1900).

may only be a somewhat abnormal variety of the more common *P. bicolor*. This form has scarcely any trace of the brown colouration so conspicuous in *P. bicolor*; it is also rather broader in proportion to the length. The second dorsal plate is as wide as the posterior part of the cephalic shield, and the posterior margins of each of the two lobes is obliquely truncated instead of being rounded as in the normal form. The lobes of the next plate, which have their posterior margins somewhat evenly rounded, are separated by a semicircular hollow and are not spread so widely apart as in the normal *P. bicolor*. The anal lamina are also more prominent than in the normal form. Till further specimens of this pale-coloured form are obtained, I prefer to regard it as only an accidental variety of *P. bicolor*.

Genus *Hatschekia,* Poche (1902).

(syn. *Clavella,* Oken, nec. Cuvier).

Hatschekia cornigera, sp. n. Pl. III., figs. 1–7.

I found this Copepod moderately frequent on the gills of several specimens of Sea Bream, *Pagellus centrodontus*, De la Roche, sent to the Laboratory from the Fish Market at Aberdeen. The species, however, does not appear to be generally common, for a considerable proportion of the fishes examined had their gills apparently free from the parasites.

Hatschekia cornigera is a small species, and measures only about 2·4 millimeters in length exclusive of the ovisacs, which are moderately elongated. It is, like some other species of the same genus, of a narrow elongated form (fig. 1), but may be distinguished from them by the cephalon being produced backwards in the form of a short blunt-pointed, spur-like process on the median dorsal aspect, as in the drawing (fig. 2), which shows a profile view of the head and part of the thorax.

The antennules are short, stout, and five-jointed, and sparingly setiferous, the third and last joints being shorter than the others (fig. 3).

The antennæ are small, but being armed with stout terminal hooked spines they form effective grasping organs (fig. 4).

The mandibles, maxillæ, and maxillipeds do not appear to differ greatly from the corresponding appendages of other members of the genus. Figure 5 represents one of the second pair of maxillipeds; they are each three-jointed, moderately elongated, and armed with a stout terminal claw which is bifurcated at the extremity; the second joint bears also a small curved spine near its proximal end; there is also a small seta at the base of the terminal claw.

The thoracic limbs comprise apparently only two pairs, as in other members of the genus. Both pairs are somewhat alike in structure, but the first are considerably smaller than the second pair. One of the first pair is represented by figure 6; it consists of a moderately stout, two-jointed basal part and two, two-jointed branches. The inner branch is rather shorter than the outer, and the first joint is shorter than the end one; in the outer branch the joints are nearly of equal length. Both branches are furnished with several stout spines. In the second pair, one of which is represented by figure 7, the inner branches are stouter and rather longer than the outer, and the end joint is about twice the length of the first. In the outer branch the end joint is the smallest. Both branches are furnished with a few terminal spines, one of which is considerably stouter and rather more elongate than the others.

The colour of the parasites resembles that of the gills of the fish.

Genus *Chondracanthus*, De la Roche.

Chondracanthus Williamsoni,* sp. n. Pl. III., figs. 8–17.

In this species the body is depressed, and of an ovate form when seen from above. Length about 7·5 millimeters, greatest width equal to about half the length. The head, which is articulated to the thorax, is subquadrangular in its general outline, but has a shallow rounded projection on each side, as shown in the figure (fig. 8). There is only a slight constriction between the cephalon and the thorax, and the neck is very short. The thorax, which is considerably depressed, has the lateral margins coarsely crenulated, or lobate; there are about six rounded but somewhat irregular projections or lobes on each side, the second and the last three being more prominent than the others. The posterior end of the thorax also terminates in a narrowly rounded median lobe, as shown in the figure (fig 8). The abdomen is much reduced in size and of a rounded form.

The antennules are small, uniarticulated, and rather rudimentary in structure (fig 10).

The antennæ are moderately large, and each consists of a stout basal part, to which is articulated a strong terminal hooked spine, the whole appendage thus forming a powerful grasping organ (fig. 11).

The mandibles are similar to those observed in other species of *Chondracanthus*; they consist each of a very short basal joint, and a terminal and broadly falciform masticatory part, both edges of which are finely serrated (fig. 12). The dilated appendage, armed with two short stout spines, situated at the base of the mandible, represents the maxilla (see fig. 12).

Both pairs of maxillipeds are very small. The first pair are very similar in structure to those of *Chondracanthus cornutus*; each consists of a moderately stout base and terminating in a straight claw-like spine, finely setose on the inner edge (fig. 13).

The second pair are rather larger than the first; they each consist of two joints of nearly equal width, but differing slightly in length, and armed at the apex with a short and claw-like spine and a small rounded process, as shown in the drawing (fig. 14).

There are only two pairs of thoracic limbs; both pairs are rudimentary, and are also similar in structure. Each limb consists of a short and broad basal part, gibbous on each side, which bears a small oblong process, separated from the basal part by a narrow constriction (figs. 15–16).

The ovisacs were not very slender, and appeared to be of moderate length, but they were more or less incomplete.

Figure 9 represents a young female which, though resembling the adult in having the lateral margins coarsely crenulated, differs in being proportionally narrower.

The male of this species is somewhat similar in form and structure to that of *Chondracanthus cornutus* (O. F. Müller). It is considerably dilated in front, but tapers towards the posterior end (fig. 17). The male is very small, being rather less than the $\frac{1}{40}$ of an inch in length.

The colour of this form is opaque white with a slight trace of red.

Host *Sebastes norvegicus* (Ascan.), from Aberdeen Fish Market, February 1908. Several specimens were found in the angles formed by the gill cover and gill-arches, with the claw-like antennæ of the specimens firmly fixed in the tissues of the host.

* After my colleague, Dr. H. C. Williamson, to whom I am indebted for this and several other species.

Sebastes norvegicus does not appear to be a very rare fish in the waters round the more northerly parts of the Scottish coasts, but the examples from which the specimens of *Chondracanthus* here recorded were obtained were captured in the vicinity of Iceland.

PLATYHELMINTHA.

Trematoda.

Genus *Octobothrium*, Leuckart (1828).

Octobothrium Sybillæ,* sp. n. Pl. IV., fig. 12.

This is a small species, being only about two and a half millimeters in length. Like some others of the same genus, it is flat, elongated, and narrow. The anterior extremity is about half the width of the middle portion of the body, and is narrowly rounded in front. There are two small submarginal suckers on the ventral aspect, one being on each side and a little in front of the mouth, which is in the median line. From the anterior end the width gradually increases towards the middle, then tapers slightly posteriorly. The posterior end expands and assumes a fan-like outline, but with the apex truncated. Round each of the two lateral margins of the fan-like expansion are four prominent "suckers." Each sucker appears to be divided into two subequal portions, as shown in the drawing (fig. 12).

A single specimen of this species of Trematode was obtained on the gills of a Trout, *Salmo fario*, Linn., captured by Dr. H. C. Williamson in Loch Tay, Perthshire, in August 1901.

Genus *Distomum*.

Distomum cestoides, Ed. van Beneden. Pl. V., fig. 12; Pl. VII., figs. 3–5.

1870. *Distoma cestoides*, P. J. van Ben. Les Poissons des cotes de Belgique, p. 17, Pl. IV., fig. 9.

P. J. van Beneden, in the work referred to above, mentions the occurrence of a large trematode in the æsophagus of *Raia batis* captured on the coast of Belgium, which he records under the name of *Distoma cestoides*. A few specimens, comprising adults and young, of what appear to be the same species of the Trematoda have been observed in large *Raia batis* brought to the Fish Market at Aberdeen. One of the adult specimens is represented by the Photograph Plate VII., fig. 3. It measures nearly two inches in length and between five and six millimeters in diameter. The specimen is cylindrical in form, and the ventral sucker is situated near the terminal one. One or two of the other specimens were even longer than that photographed, the largest measuring about two and three-quarter inches in length.

It was observed that one or two of the larger specimens were deeply pigmented immediately posterior to the ventral sucker; these when dissected were found to contain ova in abundance; the ova were of a dark chocolate-brown colour, oval in form, and measured about ·1147 × ·0806 mm. (Pl. V., fig. 12). Besides the mature specimens, others varying in size and evidently immature were also observed, the smallest of which being only six to eight millimeters long (Pl. VII., fig. 4).

* Sybilla, Queen of Alexander I. of Scotland and daughter of Henry I. of England, is buried in a small island near the east end of Loch Tay. *The Highland Tay*, by Hugh Macmillan, p. 80.

Several young specimens of a Distomum, which closely resemble the immature *D. cestoides* from the Skate, were found encysted on the walls of the stomach of a Witch Sole, *Pleuronectes microcephalus*, captured in the Moray Firth. There were several cysts observed, and all those examined contained only young Distomids—in some cases one, in others two examples. Two of the young forms and one of the cysts are shown on Plate VII., figs. 5 and 6; the figures are about twice the natural size.

Fishes form a considerable proportion of the food of large Skates, and probably the Witch Sole, which lives in moderately deep water, sometimes becomes the prey of these large Plagiostomes. Should this happen, the encysted Distomids will be liberated and reach maturity in the alimentary passages of their new host.

Several other large Distomids besides the one here referred to have been recorded as the parasites of various fishes. One of the largest, perhaps, was that obtained by Nardo in 1827, from a fish captured in the Gulf of Venice. Two specimens of this parasite were obtained, one of which measured five inches in length.* This species was named by Nardo *Distoma gigas*, but Dr. Cobbold, the English authority on Entozoa, considered that Nardo's *Distoma* belonged to the same species as that described by Rudolphi in his history of Entozoa published in 1808, under the name of *Distoma clavatum*.* The species described by Creplin as *Distomum veliporum* is also a moderately large one. It is said to attain a length of three inches, and as it has been recorded from the same species of Skate as those described above,† I was at first under the impression that those found by me might belong to that species.

Our specimens, however, agree better with van Beneden's figure in his work *Les Poissons des cotes de Belgique*, p. 17, Pl. IV., fig. 9., than with the description of *D. veliporum* in Diesing's *Systema Helminthum*. I have therefore provisionally ascribed our specimens to van Beneden's species *Distomum cestoides*.

It may be noted here that *D. veliporum* is apparently a widely-distributed species. Prof. E. Linton, of Washington and Jefferson College, U.S.A., has described in the proceedings of the U.S. National Museum (vol. xx., p. 521) a large *Distomum* from the stomach of a "Barndoor Skate," *Raia lævis*, captured at Wood's Hole, Massachusetts, which he ascribes to this species. This specimen, however, like that of *D. cestoides* recorded by van Beneden, was incomplete. The specimen recorded here is in fairly perfect condition.

Cestoda.

Genus *Bothriocephalus*, Rudolphi (1808).

Bothriocephalus proboscideus, Rudolphi. Pl. V., fig. 4.

1808. *Bothriocephalus proboscideus*, Rud., Entoz. Hist. Nat., vol. iii., p. 39.
1850. *Dibothrium proboscideum*, Dies., Syst. Helminth., vol. i., p. 590.

This Cestode was obtained in the intestine of a Trout captured in Loch Tay, in August 1901, by my colleague, Dr. H. C. Williamson. The

* See "Parasites," by T. Spencer Cobbold, M.D., p. 460; and "Systema Helminthum," Diesing, voi. ii., p. 366.

† Catalogue des Poissons des cotes de la Manche dans les environs de Saint-Vaast, par M. A.-E. Malard. Bull. Soc. Philomathique de Paris, 8 ed., Ser. t. II., p. 70 (1890).

drawing shows the anterior portion, including the head, of the specimen. The entire worm may reach a length of one or even two feet. *B. proboscideus* is one of the most common species of the genus, and is of frequent occurrence in Trout and Salmon, and, as Dr. Cobbold remarks, when the parasite is present in large numbers it cannot fail to prove injurious to the bearer.*

Bothriocephalus punctatus, Rudolphi. Pl. V., fig. 3.

1808. *Bothriocephalus punctatus*, Rud., Entoz. Hist. Nat., vol. iii., p. 50.
1858. *Dibothrium punctatum*, Dies., Syst. Helminth., vol. i., p. 593.

The specimen of *B. punctatus* represented by the drawing was obtained in the intestine of a common Eel, *Anguilla vulgaris*, Leach, captured at the mouth of the River Dee at Aberdeen in July 1905. The whole specimen measured 235 millimeters in length, or fully nine inches, but specimens double that length have been recorded. Only the head and anterior part of the body are represented by the drawing. In this species the head is elongated and narrow, and the articulations (proglottides) are also long and narrow. This parasite appears to be widely distributed, and common to a number of fishes. Professor Linton also records what he regards as the same species from several of the fishes frequenting the Atlantic coast of America, but the Eel does not appear among the various hosts mentioned by Diesing, van Beneden, or Linton. *B. punctatus* is found sometimes abundant in the Turbot, *Rhombus maximus*. I found the stomach of a large and fine Turbot crowded with them; they formed a living mass, so inextricably mixed up together, that it was almost impossible to separate one of the specimens without breaking. They extended from the stomach down into the intestines. J. P van Beneden records this parasite as abundant in the Turbot, and states that it "est tout aussi abondant dans le Turbot de la Méditerranée."† Linton records the parasite from the Sand Flounder, *Bothus maculatus*, from Woods Holl, Massachusetts; one of the longest specimens, preserved in alcohol, measured 223 millimeters; a considerable number of specimens were also found in the stomachs of Sea Raven, *Hemitripterus americanus*, the largest of which measured about 300 millimeters.‡ In report No. XIV. on the Lancashire Sea-Fisheries Laboratory, Mr. J. J. Johnston describes two forms of *B. punctatus*, one of which he finds in Turbot captured in the Irish Sea, and the other, which is more slender, in the Brill. He has counted over sixty specimens in a single Turbot.§

Genus *Ancistrocephalus*, Monticelli (1890).

Ancistrocephalus microcephalus (Rudolphi). Pl. V., fig. 5; Plate VI., fig. 2.

1819. *Bothriocephalus microcephalus*, Rud. Entozoorum Synopsis, pp. 138, 473.
1850. *Dibothrium microcephalum*, Dies., *loc. cit.*, vol. iii., p. 592.

This species was obtained from a Short Sunfish, *Orthagoriscus mola*, landed at the Aberdeen Fish Market in September 1899. The worms

* Parasites, a Treatise on the Entozoa of man and animals, p. 468.
† Les Poissons des cotes de Belgique, p. 73.
‡ Notes on Cestode parasites of fishes, Proc. U. S. National Museum, vol. xx., p. 430.
§ Report for 1905 on the Lancashire Sea-Fisheries Laboratory (1906), p. 152.

were still alive when observed, and appeared to be endeavouring to leave the fish, and making their exit by the mouth. In this species the head is comparatively small and compressed and provided with two nearly circular suckers placed opposite each other on the flattened sides, as shown in the drawing (Plate V., fig 5). Each of the suckers measure about 5 mm. in diameter, and they are surmounted by a slightly projecting ledge armed on the under side with numerous minute hook-like denticles.

One incomplete specimen measured about 26 inches in length, and another about half that length, (Pl. VI., fig. 2). According to Diesing, this Cestode may attain a length of six feet. It has been recorded by Rudolphi from *Orthagoriscus mola,* captured in the Mediterranean. Prof. Linton also records this species, and mentions one of the specimens as being 150 centimetres long (nearly sixty inches). Van Beneden records the same worm from the coast of Belgium, and states that he has seen a score of individuals in a single fish,* while Malard also records it from the coast of La Manche, and apparently all from the same species of Sunfish.

Genus *Schistocephalus,* Creplin (1829).

Schistocephalus solidus (O. F. Müller). Pl. VII., figs. 7–8.

1776. *Tœnia solida,* O. F. Müller, Zool. Danicæ Prodromus, pp. 26–37.
1808. *Bothriocephalus solidus,* Rud., Entozoörum, Hist. Nat., p. 54.
1829. *Schistocephalus dimorphus,* Crep., Nov. obs. de Entoz., p. 95.
1850. *Schistocephalus dimorphus,* Dies., Syst. Helminth., vol. i., p. 584.
1893. *Schistocephalus dimorphus,* Ölsson, Bidrag till Skand Helminth fauna, ii., p. 15.
1896. *Schistocephalus solidus,* F. W. Gamble, in the Camb. Nat. Hist., vol. ii., p. 84.

The three-spined Stickleback, *Gasterosteus aculeatus,* is a little fish not uncommon in the Loch of Loirston, near the village of Cove, Kincardineshire. On visiting this loch towards the end of May 1901, my colleague, Dr. H. C. Williamson, found a large proportion of the Sticklebacks infested with worms, so much so that many of the little fishes had their abdomens distended with the parasites, causing them to assume an abnormal appearance. Many of the fishes examined had the entire abdominal cavity occupied by the parasites. In some cases there was only a single worm of large size, folded upon itself two or three times, and which, when straightened out, was much longer than the fish. In other cases two, and sometimes several, specimens were present, but these were generally of smaller size.

The loch is frequented by a number of water-birds such as Sea-gulls and Terns, and the Heron is also occasionally observed about the loch. These birds are liable to be infested with the tape-worm, *Schistocephalus solidus,* Rudolphi, in its sexually-mature stage, and the Stickleback parasite mentioned above is the same worm in its sexually-immature condition.

It is thus evident that some of the birds frequenting the loch had been giving shelter to the *Schistocephalus,* and that larvæ hatched from the

* Les Poissons des cotes de Belgique, 87.

eggs produced by the mature worm had found their way by some roundabout road to the abdomen of the fish, there to continue the cycle of their curious and highly interesting life-history.

Figure 7, Plate VII., is a photograph of one of the little fishes infested with the parasite showing the distended abdomen, and figure 8 is the photograph of another fish showing the worms *in situ*.

This Cestode is apparently widely distributed; not only has it been recorded under one or other of its different names by European writers on Helminthology, but Prof. Edwin Linton mentions its occurrence in the abdominal cavity of the Blob, *Cottus bairdii*, captured in Swan River, Montana, August 3rd, 1891. (Proc. U.S. National Museum, vol. xx., p. 427, pl. xxviii., figs. 4–5.)

Genus *Tetrarhynchus*, Rudolphi (1808).

Tetrarhynchus megacephalus, Rudolphi. Pl. IV., figs. 9–10; Pl. VI., fig. 3.

1819. *Tetrarhynchus megacephalus*, Rud. Entozoorum Synopsis, p 129 et 447. Tab. II., fig. 7–8.

1878. *Tetrarhynchus megacephalus*, Van Ben., Pois. d. cotes. d. Belgique, p. 12, Pl. VI., figs. 8, 9–15.

This *Tetrarhynchus* is one of the largest of this curious group of parasites; the specimen represented by the photograph (Pl. VI., fig. 3) measured about eighteen inches in length, and nearly half an inch in width. It was obtained by my son in the intestine of a Greenland Shark, *Scimnus borealis*, Flem., captured at the mouth of the Forth estuary many years ago. This parasite has also been found, but in a sexually-immature state, in the Blue Shark, *Carcharias glaucus*, and some other species of the shark family;* but though it appears to be limited in its distribution chiefly to that group of Selachians, it has also been recorded as occurring in other fishes, one of which is *Scorpaena porcus*, a Mediterranean fish. Van Beneden remarks that the same worm, or a near ally, has been found on the gills of a Sparoïde, as well as in the mouth of a turbot; but, he adds, "Dans cette situation le ver est errant." †

Tetrarhynchus tetrabothrius, P. J. van Beneden. Pl. IV., fig. 11.

1850. *Tetrarhynchus tetrabothrium*, van Ben., Les Vers Cestodes, *l'Acad. Roy. de Belgique*, Tom. XXV., p. 154, Pl. XVIII.

This was obtained in the intestine of Picked Dog-fishes, *Squalis acanthias*, Linn., examined at the Laboratory in March 1902. The fishes had been captured in the North Sea and landed at the Fish Market at Aberdeen. In these Dog-fishes this parasite was of frequent occurrence, being observed in nearly all the specimens examined. Van Beneden also records the ocurrence of this Cestode in the same species of Dog-fish, as well as in *Mustelus vulgaris*, taken off the coast of Belgium. ‡ Olsson has recorded *T. tetrabothrius* from Picked Dog-fishes captured in the Skagar-

* This Tetrarhynchus, in Dr. Baird's catalogue of Entozoa in the British Museum, is recorded from a large Spotted Dog-fish, *Scyllium catulus* (p. 68).

† Les Poissons des cotes de Belgique, p. 5.

‡ Les Poissons des cotes de Belgique, pp. 6–10.

rack and Öresund * and Johnston from similar Dog-fishes and from Thornback Skates, trawled in the Irish Sea.†

Tetrarhynchus minutus, P. J. van Beneden. Pl. V., figs. 7–8.

1850. *Tetrarhynchus minutus,* van Ben., Les Vers Cestodes, p. 157, Pl. XX.

This Cestode was obtained in the intestine of an Angel-fish, *Squatina angelus*, captured in the Firth of Clyde in May 1904; it is a small species and easily overlooked. As indicated above, this species was described by van Beneden in 1850, and the characters by which he distinguishes it are as follows :—"Les bothridies ne sont pas complétement séparées les unes des autres; les trompes sont couvertes de crochets recourbés; les gaînes des trompes forment des tours de spire; les segments sont très-longs et peu nombreux," and he adds that the species may be recognised from closely-allied forms by its small size, the length of the segments, which are several times longer than broad, and the number of articulations, which seldom exceed six, the last segment being already mature when five or six rings can be counted, whereas in other species mature segments do not usually occur till a larger number of rings have been formed. Van Beneden's specimens of *T. minutus* were also obtained from *Squatina angelus*, which appears to be the only kind of fish this Cestode has been recorded from.

Another species of *Tetrarhynchus—T. erinaceus*, P. J. Van Beneden, described in 1858,‡ has been noticed in fishes examined at the Laboratory, usually in small cysts on the walls of the stomach, and pyloric cæca of Gadoids (Cod-fishes and Saithe). *T. erinaceus*, in this encysted state, according to van Beneden, is unable to attain sexual maturity, and is therefore placed by him among the *zenosites* or strangers—parasites that have not yet reached their ultimate destination, or, as that author remarks, "Ce sont des parasites en transit." The encysted *Tetrarhynchus* can only reach the sexually mature stage after it has been transferred to the stomach of some Plagiostome, and the fish belonging to that group in which the parasite has been most frequently observed in a sexually mature condition is the Thornback Skate, *Raia clavata*. The proboscides do not appear to be exserted while the parasite remains within its cyst, but when removed from it and placed in a little sea-water the Cestode, apparently recognising the change in its environment, soon begins to push out its formidably armed proboscides. So far as I have observed, the thrusting out of these armed appendages is not completed by a continuous movement, but intermittently, as if the operation were a work of some difficulty, and that a pause was necessary for further effort. I have also observed that, though the fish may have been dead for a good while, the encysted parasite would be still alive, and on being removed from its prison would in a short time begin to thrust out its proboscides. *T. erinaceus* is a widely-distributed species, either in its encysted state or in its state of sexual-maturity, for it has been recorded not only by van Beneden, Ölsson, and other European Helminthologists, but also by Linton in his papers on the Entozoa of American fishes.

Two of the species of *Tetrarhynchus* mentioned here—*T. tetrabothrius* and *T. minutus*—have also been assigned to the genus *Rhynchobothrium*, Rudolphi, but meanwhile I leave them where van Beneden placed them.

* Bidrag till Scandinaviens fauna, *Kongl. Sv. vet. Akad. Handl.*, Bd. 25, No. 12, p. 25 (1893).

† Rept. for 1905 of the Lancashire Sea Fisheries Laboratory, p. 174 (1906).

‡ Mem. sur les Vers intestineaux, p. 128, Pl. XVIII.

Genus *Phyllobothrium*, P. J. van Beneden (1850).

Phyllobothrium thridax, van Beneden. Pl. V., fig. 9.

1850. *Phyllobothrium thridax*, Les Vers Cestodes, p. 122, Pl. V.
1906. *Phyllobothrium thridax*, Johnston, Report for 1905 of the Lancashire Sea Fisheries Laboratory, p. 161.

This Cestode was obtained in the intestine of the same fish in which the *Tetrarhynchus minutus* was observed, viz., in *Squatina angelus*, captured in the Clyde near Girvan in May 1904. The specimen was small and appeared to be immature, though possessing the characters of the species.

Van Benden obtained *P. thridax* also in the Angel-fish, as well as in *Raia batis*, and Johnston records it from *Raia clavata* captured in the Irish Sea. Olsson has recorded the same Cestode from *Raia batis* captured in the Öresund, and Lönnberg and Monticelli have also recorded it, but it does not appear to be so common as some of the others mentioned here.

Phyllobothrium lactuca, P. J. van Beneden. Pl. V., fig. 1.

1850. *Phyllobothrium lactuca*, van Ben., *op. cit.*, 120, Pl. IV.
1906. *Phyllobothrium lactuca*, Johnston, *op. cit.*, p. 159.

This was also observed in the Angel-fish from the Clyde mentioned above. Johnston records it from *Raia batis*, *Raia clavata*, and *Raia circularis* captured in the Irish Sea. Van Beneden states that it is common in the Smooth Hound, *Mustelus vulgaris*, and records it also from the Picked Dog-fish, the Grey Skate, and the Thornback, and Malard records it from *Trygon vulgaris* and one or two of the Plagiostomes already referred to

Genus *Acanthobothrium*, P. J. van Beneden (1849).

Acanthobothrium coronatum (Rudolphi). Pl. V., fig. 2.

1819. *Bothriocephalus coronatus*, Rud., Entozoorum Synopsis, p. 141.
1850. *Acanthobothrium coronatum*, van Ben., *op. cit.*, p. 129, Pl. VIII. and IX.
1906. *Acanthobothrium coronatum*, Johnston, *op. cit.*, p. 155.

I obtained this species in specimens of Grey Skate, *Raia batis*, from the Fish Market, Aberdeen, in March 1901. The specimen, of which only the head (or scolex) is represented by the drawing (fig 2), measured sixty-five millimeters in length. One of the more important characters by which *A. coronatum* is distinguished seems to be the presence of a group of three suckers above each of the four *bothria*. These accessory groups of suckers form a sort of crown on the apex of the scolex, while immediately beneath each group two moderately strong bifid hooks may be seen, as indicated in the drawing.

This species is found in the sexually-mature stage in various sharks and rays, and is apparently widely distributed. The following European fishes are mentioned among the hosts of this Cestode :—*Scyllium canc ula*, the lesser Spotted Dog-fish; *Mustelus vulgaris*, the Smooth Hound; *Squatina angelus*, *Trygon pastinaca*, *Torpedo marmorata*, *Raia batis*,

and *Raia clavata*; while Linton records the same parasite from the Barn-door Skate, *Raia laevis*, captured at Woods Hole, Massachusetts.

Genus *Dinobothrium*, P. J. van Beneden (1889).

Dinobothrium septaria, van Beneden. Pl. VI., fig. 4.

1889. *Dinobothrium septaria*, van Ben., Bull. l'Acad. Roy. de Belgique, 3me. série., tom. 17, p. 69, Pl. I., figs. 1–3.

The specimen represented by the photograph Plate VI., figure 4, is from the intestine of a Porbeagle Shark, *Lamna cornubica*, captured in the North Sea in May 1901. The specimen measures about forty-five millimetres in length. Each pair of bothria measure about nine millimetres across by about seven millimetres in length. This Cestode is readily distinguished by the peculiar form and arrangement of the bothria from all other species belonging to this group of parasites. As the species does not appear to have been previously recorded from Scottish waters, it may be of interest to give the following extract from Prof. van. Beneden's description. The scolex, he says, is surrounded with four bothria, as in the majority of the Cestodes of Sharks and Rays; these bothria are placed back to back, and possess no appearance of hooks. The worms having been preserved in alcohol had become somewhat contracted, and the form of the bothria was not unlike a shell of the genus *Septaria*. These bothria are large, of an oval form, and attached by the whole length of their base; the external face is concave and crowned above by a projection which in some respects resembles the hinge of certain bivalve shells.*

The specimens recorded by van Beneden measured twenty-five to thirty millimeters, and were thus considerably smaller than the specimen recorded here.

Genus *Diplobothrium*, P. J. van Beneden (1889).

Diplobothrium simile, van Beneden. Pl. VII., fig. 2.

1889. *Diplobothrium simile*, van Ben., *op. cit.*, p. 70, Pl. I., figs. 4–8.

A specimen of a Cestode that appears to belong to this species is represented by the photograph, Plate VII., figure 2. This, like the species just described, was obtained in the intestine of the same Porbeagle Shark in which the other was found. The specimen measured fully 70 millimeters in length—nearly three inches.

This Cestode was described by van Beneden at the same time as the *Dinobothrium*, and was also found in a Porbeagle Shark. The Scolex or "head" does not at first sight present so remarkable a form as the *Dinobothrium*, but its structure suggests a more or less near relationship with species already known to science. A closer examination, however,

* Le scolex est entouré de quatre bothridies, comme dans la plupart des Cestodes de poissons Plagiostomes; ces bothridies sont placées dos à dos et ne possèdent aucune apparence de crochets. Dans l' état de conservation actuelle des vers, contractés par l' alcool, elles ressemblent, à une coquille du genre *Septaria*.

Les bothridies sont larges, de forme ovale, attachées par toute la largeur de la base, la face externe concave et couronnées en haut par une saillie qui rappelle jusqu'à un certain point, la charnière de certaines coquilles bivalves. Van Beneden, *op. cit.*, p. 69.

reveals certain interesting differences, which are fully described by Professor van Beneden in the paper referred to, published in the Bulletin of the Royal Academy of Belgium for 1889.

In this paper he remarks that at first sight it suggested to him a likeness to *Tetrabothrium maculatum*, Ölsson, a form previously recorded from the same kind of fish, and therefore he gave the species the name of *Diplobothrium simile*—the generic name *Diplobothrium* referring to the peculiar arrangement of the bothria. He states further that "ce qui caractérise surtout ce genre, c'est qu'il a, comme le précédent, une cloison complète entire les deux couples of bothridies; cette cloison présente à son sommet quatre pièces qui semblent fournir des points d'appui à la couche musculaire; sous certains aspects, ce Cestode resemble beaucoup au Cestode, dont nous venons de parler, et qui a été décrit par Olsson; mais les organes qui lui ont fait donner le nom de Tetrabothrium sont complétement isolés, tandis que dans le *Diplobothrium* ils sont réunis deux par deux; à l'extérieur on croirait voir par moments quatre orifices parfaitement séparés, tandis qu'en réalité il y'a, de chaque côté, une séparation qui ne s'étend pas jusqu'au bord des orifices."

Genus *Abothrium*, P. J. van Beneden (1870).

Abothrium rugosum (Goeze).

1782. *Taenia rugosa*, T. A. S. Goeze, Versuch siner Naturg. der Eingeweidervürmer thierscher Korper, p. 411. Tab. xxxiii., figs. 1–5.

1808. *Bothriocephalus rugosus*, Rudolphi, Entoz. Hist. Nat., Vol. III., p. 42.

1850. *Dibothrium rugosum*, Diesing, Syst. Helminth, Vol. I., p. 591.

1870. *Abothrium gadi*, van Beneden, Poissons des cotes de Belgique p. 56, Pl. V., fig. 14.

This Cestode appears to be common in the sexually-mature stage in the larger gadoids. Its head is invariably inserted in one of the cæcal tubes and so intimately incorporated with its tissues as to have the appearance of forming an integral part of the tube. For this reason, the attempts made to remove the head of the worm from the tissues of the pyloric cæca have usually ended in failure, and no satisfactory description of this part of the worm has yet been published.

The piercing of the wall of the pyloric cæca by the head of the Cestode produces certain curious results; the cæcal tube becomes distorted sometimes to a considerable extent, nodular processes are formed, and frequently, as remarked by Linton, a yellowish waxy deposit is formed consisting of the degenerated tissue of the cæca. The worm, which extends from the cæcal tube to the intestine, is often in the larger fishes of considerable length; specimens from such fishes sometimes reach to twenty-five and thirty inches, but as, like most other Cestodes, they are very contractile, the specimen that may, while living, stretch to thirty inches will be found to be little more than half that length when preserved, especially if the preservative be alcohol. Linton records a specimen 65·5 millimeters in length, while Johnston obtained one that measured 85 centimeters,* equal to about 34 inches.

* Report for 1906 on the Lancashire Sea Fisheries Laboratory, p. 171.

Genus *Taenia*, Linné.

Taenia sp. Pl. V., figs. 10–11.

A specimen of a Cestode that appears to belong to the genus *Taenia* was obtained in the intestine of an Eel captured in the Loch of Loirston, near Cove, Kincardineshire, in 1901. The specimen measured about 75 mm. in length, and was moderately slender. The head seen in front is obscurely quadrangular, with the bothria occupying the bluntly-rounded corners, and nearly equidistant. In the centre is a minute stellate disk, somewhat difficult to make out. The bothria are circular, surrounded by a muscular ring, and with a membrane extending over the inner half. The head appears to be unarmed. This specimen has some resemblance to a form mentioned by Linton found in the intestine of "*Anguilla chrysypa (Anguilla vulgaris)*," and named by him *Taenia dilatata*.* The Loch of Loirston specimen may belong to this species, but I scarcely think so; the *T. dilatata* Linton, shows the front aspect of the head made uneven by shallow "dilatations" which is not the case with the specimen recorded here. I therefore prefer for the present to leave the species unnamed.

NEMATHELMINTHA.

Sub-Order Acanthocephala, Rudolphi.

Genus *Echinorhynchus*.

Echinorhynchus proteus, Westrumb. Pl. IV., figs. 3–4; Pl. VI., fig. 1.

1821. *Echinorhynchus proteus*, Westrumb, De Helminth. Acanth., p. 37, tab. 1, figs. 11–12.

1850. *Echinorhynchus proteus*, Diesing, Syst. Helminth., Vol. II., p. 57.

This curious species was observed in the intestine of an Eel, *Anguilla vulgaris*, Cuv., captured near the mouth of the River Dee at Aberdeen in July 1905. In this species the proboscis is short and feebly armed; it is also sub-clavate in form, rather linear or cylindrical. Immediately posterior to the proboscis is a large bulb-like expansion (or *bulla*), which the parasite seems to have the power to compress or dilate at will, for it can insert not only the proboscis but the bulla also into the tissues of the muscus membrane of the intestine, as shown by the photograph (Pl. VI., fig. 1). This figure represents a small portion of the inner surface of the intestine of of the Eel with two *Echinorhynchi in situ*; the proboscis and *bulla* of the parasites are entirely immersed in the substance of the intestinal wall. A careful examination of the fish revealed the fact that in a few instances the proboscis of the parasite had pierced right through the intestine so that the apex of the proboscis could be easily seen projecting slightly on the outside surface of the wall of the intestine.

Between the *bulla* and the body of the Cestode there is a long slender neck, and both the *bulla* and the neck are unarmed.

The length of the specimen represented by the drawing (Pl. IV., fig. 3), is sixteen millimeters, or fully half an inch.

* Parasites of Fishes of the Woods Hole region, *U.S. Fish Commission Bull. for* 1899, p. 435, Pl. XXV., figs. 272–273.

Echinorhynchus proteus, being a widely distributed and apparently a somewhat variable form, has been described under many different names. It has also been recorded from many kinds of fishes, both marine and freshwater; at least over forty different kinds are mentioned as being the hosts of this worm.*

Echinorhynchus acus, Rudolphi. Pl. IV., figs. 7–8.

1808. *Echinorhynchus acus*, Rudolphi, Entoz. Hist. Nat., Vol. II., p. 279.

1850. *Echinorhynchus acus*, Dies., Syst. Helminth., Vol. II., p. 39.

Many examples of this *Echinorhynchus* were observed in the intestine of a large cod-fish captured in the Moray Firth in June 1897, and though frequently observed at other times and places, the species has not been represented so numerously as on that occasion. They were found fairly numerous in the intestine of a saith captured recently in the nets of the salmon fishers working near the Laboratory.

Although the hosts of *Echinorhynchus acus* are said to include a number of different kinds of fishes such as *Cottus scorpius*, the Conger, the Angler-fish, and one or two kinds of flat-fishes, this parasite seems to be more frequently met with in Gadoids than in any other fishes captured off the coasts of Scotland.

In this species the hooks with which the proboscis is armed are numerous and large; they are arranged in close set and slightly oblique rows. There are about twenty hooks in a complete series extending once round the circumference, but scarcely half that number are in view at one time. Each hook is bent backwards at a sharp angle, as shown in the drawings (figs. 7 and 8). The length of this species, as given by Diesing, is from one to three inches; the largest I have noticed, however, scarcely exceeded 50 millimeters in length.

The *Echinorhynchus* represented by the drawings, figures 5 and 6 on Plate IV., was obtained in the intestine of a common Trout captured in Loch Tay in August 1901. The number of hooks in the series is rather less than in the specimen from the Gadoid—the number in view at one time being eight. But it so closely resembles *Echinorhynchus acus* that it is probably only a variety or a slightly immature form of that species.

Echinorhynchus agilis, Rudolphi. Pl. IV., figs. 1–2.

1819. *Echinorhynchus agilis*, Rud., Entozoorum, Synopsis 67 et 316.

1850. *Echinorhynchus agilis*, Diesing, Syst. Helminth., Vol. II., p. 35.

Diesing's definition of this species is as follows:—"*Proboscis clavata, uncinorum seriebus* 3. *Collum brevissimum inerme. Corpus utrinque attenuatum, densissime transversim striatum. Longit.* 2–3." And he mentions as the hosts of this entozoon *Mugil cephalus*, captured at Spezia (Gulf of Genoa), and *Mugil labeo*, captured at Remi. This description by Diesing applys fairly well to an *Echinorhynchus* observed in the intestine of a Grey Mullet, *Mugil chelo*, captured in the nets of the salmon fishers near the Laboratory in June 1900. One of the specimens is repre-

* Linton has also observed *E. proteus* in a number of American fishes.

sented by the drawings (figs. 1 and 2, Pl. IV.). The body tapers slightly towards both ends, and is marked by numerous transverse striæ, and thus far it agrees with the definition of *E. agilis* of Diesing; there seems, however, to be a slight difference in the number of hooks on the proboscis, of which there are apparently six in the series instead of three. The hooks as shown in the drawing are of moderate size; those surrounding the summit of the short truncated proboscis extend more or less outwards, while the others, which spring from about the middle and have stout gibbous bases, are turned downwards.

I was at first inclined to ascribe this form to *Echinorhynchus gracilis*, van Beneden, as the proboscis and its armature resemble somewhat closely that author's figure in Plate V. of his work on the Fishes of the Coasts of Belgium,* which species he also obtained in the intestine of *Mugil chelo*, but I scarcely think that van Beneden's *E. gracilis* can be the species of that name which Diesing ascribes to Rudolphi, for Diesing's definition of Rudolphi's *Echinorhynchus gracilis*, is as follows:—" *Proboscis cylindrica, uncinorum minutorum seriebus,* 10-12. *Collum nullum. Corpus cylindricum retrorsum attenuatum,*" † and there is no reference to transverse striæ. Moreover, the *Echinorhynchus gracilis*, Rudolphi, is, according to Diesing, found in the intestine of a bird, *Coracias garrula*, Linn. et Gmel. I have, therefore, for the several reasons stated, referred our specimens to *Echinorhynchus agilis*, Rudolphi.

SOME ADDITIONAL NOTES.

(1) On a large Cestode from the intestines of a Common Porpoise.

Diphyllobothrium stemmacephalum, Cobbold, Pl. V., fig. 6; Pl. VII., fig. 1.

1858. *Diphyllobothrium stemmacephalum*, Cobbold, Trans. Linn. Soc., vol. xvii., p. 167.

1879. *Diphyllobothrium stemmacephalum*, idem, Entozoa of Man and Animals, p. 422.

This large Cestode was obtained in the intestines of a Common Porpoise, *Delphinus phocæna*, cast ashore in front of the Laboratory at the Bay of Nigg. The porpoise had become entangled in the nets belonging to the salmon fishers, and being unable to extricate itself had been drowned. Dr. Cobbold, who described the Cestode in 1855, and who also obtained it in the same species of Cetacean, states that " the small intestine of the Porpoise was completely choked for the space of eight or nine feet by fine tapeworms so closely packed together that the gut presented the appearance of a solid cylinder." These tapeworms, he remarks, were of various sizes; four of them measured respectively from seven to ten feet in length, while a fifth was only eighteen inches.

The Porpoise cast ashore near the Laboratory, and which I had the privilege to examine, had the small intestine also crowded with the same kind of parasites, and so much so that it seemed to be impossible that any matter could pass, yet the Cetacean had the appearance of being in perfect health. The removal of the parasites in anything like a complete condition was very difficult owing to their great length, their being so crowded together, the extreme attenuation of the anterior end with its

* Les Poissons des cotes de Belgique, p. 28, Pl. V., fig. 7 (1870).
† Systema Helminthum, vol. ii., p. 37 (1850).

minute head, and the readiness with which the lower "joints" (proglottis), separated from each other. The longest example I obtained measured fully nine feet, and appeared to be fairly complete. Another specimen reached to about seven feet in length, and there were a number of smaller pieces.

The proglottides or "joints" near the middle and towards the posterior end of the larger specimens measured from ten to twelve millimeters in width and nearly the same in length. The head or scolex seen in profile is very compressed, but viewed in front its outline is somewhat triangular, and the suckers—two in number—occupy the two sides of the triangle, as shown in the drawing (fig. 6, Plate V.). The neck is extremely slender, measuring only about ·08 mm. in width.

There appears to be very little known concerning the life-history of this Cestode, but probably in its larval stage it lives encysted in the body of some species of fish such as the whiting, considerable numbers of which are sometimes captured by this Cetacean for food; the Cestode being in this way introduced into the stomach of the Porpoise would obtain its freedom and be able ere long to attain to sexual maturity in the intestine of its new host.

Figure 1, Plate VII., is from a photograph, about natural size, of the largest of the specimens of the *Diphyllobothrium*, from the Porpoise referred to. The Cetacean was obtained in May 1900.

(2) On Nematodes or Threadworms observed in the stomach and other viscera of a Common Porpoise.

In another Porpoise obtained on June 18th, 1902, under much the same conditions as the one mentioned above, no Cestodes of any kind were observed, but in the stomach and some of the other internal organs many small threadworms were noticed. The length of some of these measured between forty-five and fifty millimeters, but the majority were considerably smaller. The worms occurred in abundance in the stomach and other portions of the viscera, and were of a dull reddish-brown colour.

Strongyloid Nematodes, known as Lung-worms, are found parasitic in the Common Porpoise; they are all viviparus. Three species have been recorded, *Prosthecosacter inflexus*, Diesing, measuring 6 to 9 inches in length; *P. minor*, Diesing, the length of which is about an inch; and *P. convolutus*, Diesing, the length of which may extend to a little over one and a half inches (18–20^{m}).

Dr. Cobbold, referring to these worms, states that when "they are examined in a fresh state the young may occasionally be seen escaping from the vagina, ... that Professor van Beneden noticed this phenomenon in *Prosthecosacter inflexus*, and the same was observed by Busk in *P. convolutus.*" *

The Entozoa from the Porpoise examined at the Laboratory in 1902, like those mentioned above, are apparently also viviparous, and they agree fairly well with the species last named—*P. convolutus*, Diesing.

Though the specimens when removed from the Porpoise were still alive, they had to be put into preservative fluid straight away, and therefore I had not the good fortune to observe the phenomenon referred to by Cobbold. Afterwards, however, when a few of them were dissected, fully formed larvæ were obtained in considerable numbers.

Figure 13, Plate V., represents the posterior portion of a female specimen showing the larvæ *in situ*. Figures 13 a., b., and c. represent three

* Entozoa of Man and Animals, p. 423.

of the larvæ greatly enlarged, while figure 6, Plate VI., represents a small portion of the viscera crowded with the parasites and figure 7 on the same plate shows a few of them separated out; both of these figures are from photographs enlarged about twice the natural size.

Like most of the Entozoa mentioned in the preceding notes, these parasites of the Porpoise are in their early stages probably migrants, but little or nothing appears to be known concerning their life-history. In Dr. Cobbold's opinion "it is highly probable that the embryos enter the bodies of various fishes before they acquire sexual maturity. Thence they will be passively transferred to the stomachs of cetacea, whence they bore their way through the tissues to the bronchi and pulmonary vessels," and thus reach the goal of all their wanderings—an environment where they can accomplish the purpose of their life, viz., the development of young, on which in their turn will devolve the responsibility for their continuance of the species.

(3) On the Injurious Effects of Parasites on Fishes infested by them.

In the many cases of parasitism that have come under my observation, I have usually been unable to notice any very serious results produced by the presence of such unbidden and, perchance, unwelcome guests. Occasionally evidence of injury apparently caused by them has been obtained.

Whitings and other Gadoids have been captured reduced almost to skin and bone, having one or more large worm-like *Lernæa* hanging at their gills full of the red blood they had extracted therefrom. Yet, even in cases like these, it may be a moot point whether the emaciation is caused by the *Lernæa*, or that their presence is simply owing to the emaciated condition of the fish—the emaciation itself being due to other causes—which by reducing the fishes' vitality has left it more exposed to the attacks of these parasites. But though there may be no direct proof that the emaciated condition referred to was caused by these crustacean parasites, their presence doubtless tended to aggravate the trouble, and the same may be said about the attacks of parasites in other directions. The next example of parasitism to which I have to refer shows how these vermin (fishermen have a more suggestive name for them) may be injurious to fishes in other ways. Figure 5, Plate VI., reproduced from a photograph, represents the pectoral fins of a flounder infested with crustacean parasites, *Lepeophtheirus pectoralis*. They are so numerous that a large portion of both fins is covered by them. The soft tissues of the fins, more especially round the edges and between the spiny rays, was extensively lacerated, and this with the added encumbrance of so many beasts hanging on to them must have interfered greatly with their movements. These parasites are usually found adhering to the underside of the fins, and in this position they are more sheltered and less likely to be rubbed off, and the irritation they may produce will be the more exasperating.

A careful scrutiny of the photograph shows considerably over a hundred specimens of the *Lepeophtheirus* adhering to the pair of fins; they are so crowded towards the outer edges of the fins that they overlap each other two or three deep, and the delicate margin of the fins has been destroyed.

EXPLANATION OF THE PLATES.

PLATE III.

Hatschekia cornigera, sp. n.

		Diam.
Fig. 1.	Female, dorsal view,	× 40
Fig. 2.	Female, side view of cephalothorax,	× 80
Fig. 3.	One of the antennules,	× 410
Fig. 4.	One of the antennæ,	× 410
Fig. 5.	One of the maxillipeds,	× 550
Fig. 6.	Foot of first pair,	× 550
Fig. 7.	Foot of second pair,	× 410

Chondracanthus Williamsoni, sp. n.

Fig. 8.	Female, dorsal view (adult specimen),	× 12
Fig. 9.	Female, dorsal view (specimen scarcely mature),	× 13½
Fig. 10.	One of the antennules,	× 72
Fig. 11.	One of the antennæ,	× 72
Fig. 12.	Mandible and maxilla,	× 200
Fig. 13.	First maxilliped,	× 144
Fig. 14.	Second maxilliped,	× 144
Fig. 15.	One of the first pair of thoracic appendages,	× 36
Fig. 16.	One of the second pair,	× 36
Fig. 17.	Male, side view,	× 120

Pandarus bicolor, (?) var.

Fig. 18.	Female, dorsal view,	× 12

Pandarus bicolor.

Fig. 19.	Female, dorsal view,	× 12

PLATE IV.

Fig. 1.	*Echinorhynchus agilis*, Rudolphi,	× 15
Fig. 2.	Proboscis of the same,	× 136
Fig. 3.	*Echinorhynchus proteus*, Westrumb,	× 12½
Fig. 4.	Proboscis of the same,	× 72
Fig. 5.	*Echinorhynchus*, sp. from a common trout,	× 10
Fig. 6.	Proboscis of the same (6*a* a spine more enlarged),	× 50
Fig. 7.	*Echinorhynchus acus*, Rudolphi,	× 11
Fig. 8.	Proboscis of the same,	× 96
Fig. 9.	*Tetrarhynchus megacephalus*, Rudolphi (Scolex),	× 5
Fig. 10.	A proboscis of the same,	× 28
Fig. 11.	*Tetrarhynchus tetrabothrius*, van Beneden,	× 24
Fig. 12.	*Octobothrium Sybillæ*, n. sp.,	× 70

PLATE V.

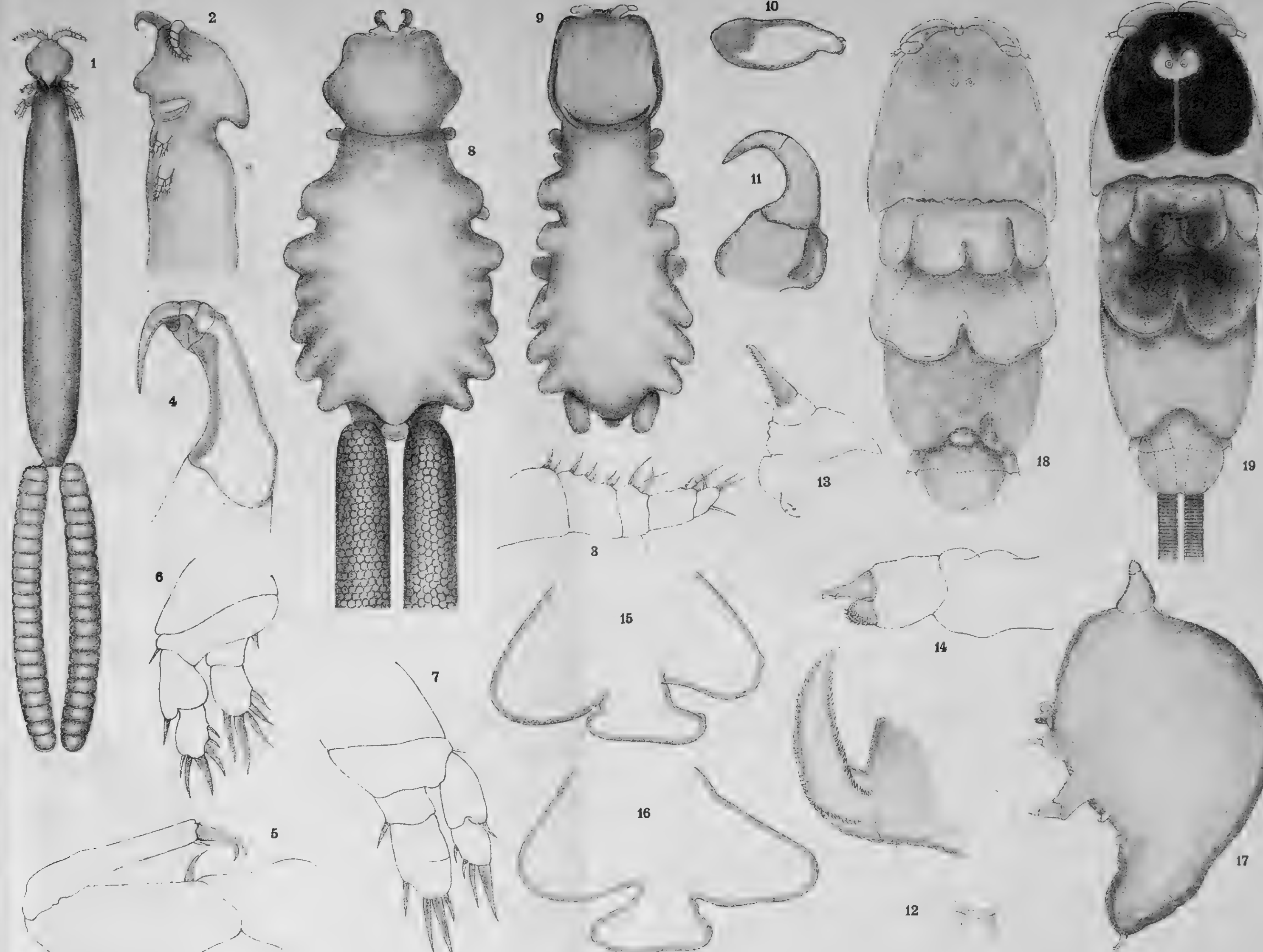
Fig. 1.	*Phyllobothrium lactuca*, van Beneden,	× 48
Fig. 2.	*Acanthobothrium coronatum*, van Beneden,	× 48
Fig. 3.	*Bothriocephalus punctatus*, Rudolphi,	× 25
Fig. 4.	*Bothriocephalus proboscideus*, Rudolphi,	× 48
Fig. 5.	*Ancistrocephalus microcephalus*, Rudolphi,	× 36
Fig. 6.	*Diphyllobothrium stemmacephalum*, Cobbold,	× 60
Fig. 7.	*Tetrarhynchus minutus*, van Beneden,	× 72
Fig. 8.	Portion of a proboscis of the same, near proximal end,	× 615
Fig. 9.	*Pyllobothrium thridax*, van Beneden,	× 72
Fig. 10.	*Tænia* sp. from a common Eel,	× 48
Fig. 11.	Head of the same seen from above,	× 108
Fig. 12.	An ovum of *Distomum cestoides*, van Beneden,	× 410
Fig. 13.	(?) *Prosthecosacter* sp., posterior end of ♀ with larvæ *in situ*,	× 74
Fig. 13.	a. b. c., Three larvæ of the same removed,	× 340

PLATE VI.

Fig. 1. *Echinorhynchus proteus* with their heads embedded in Eel intestine, - - - - - - slightly enlarged.
Fig. 2. *Ancistrocephalus microcephalus* (Strobile), - slightly enlarged.
Fig. 3. *Tetrarhynchus megacephalus*, (Strobile), - - slightly enlarged.
Fig. 4. *Dinobothrium septaria*, van Beneden, (Strobile), - - × 2
Fig. 5. *Lepeophtheirus pectoralis*, adhering to pectoral fins of flat fish, -
Fig. 6. (?) *Prosthecosacter* in viscera of Porpoise, - - - × 2
Fig. 7. Specimens of the same shown separately, - - - - × 2
Fig. 8. *Echinorhynchus acus*, with their heads embedded in intestine of Coal-fish, - - - - - - - × 2

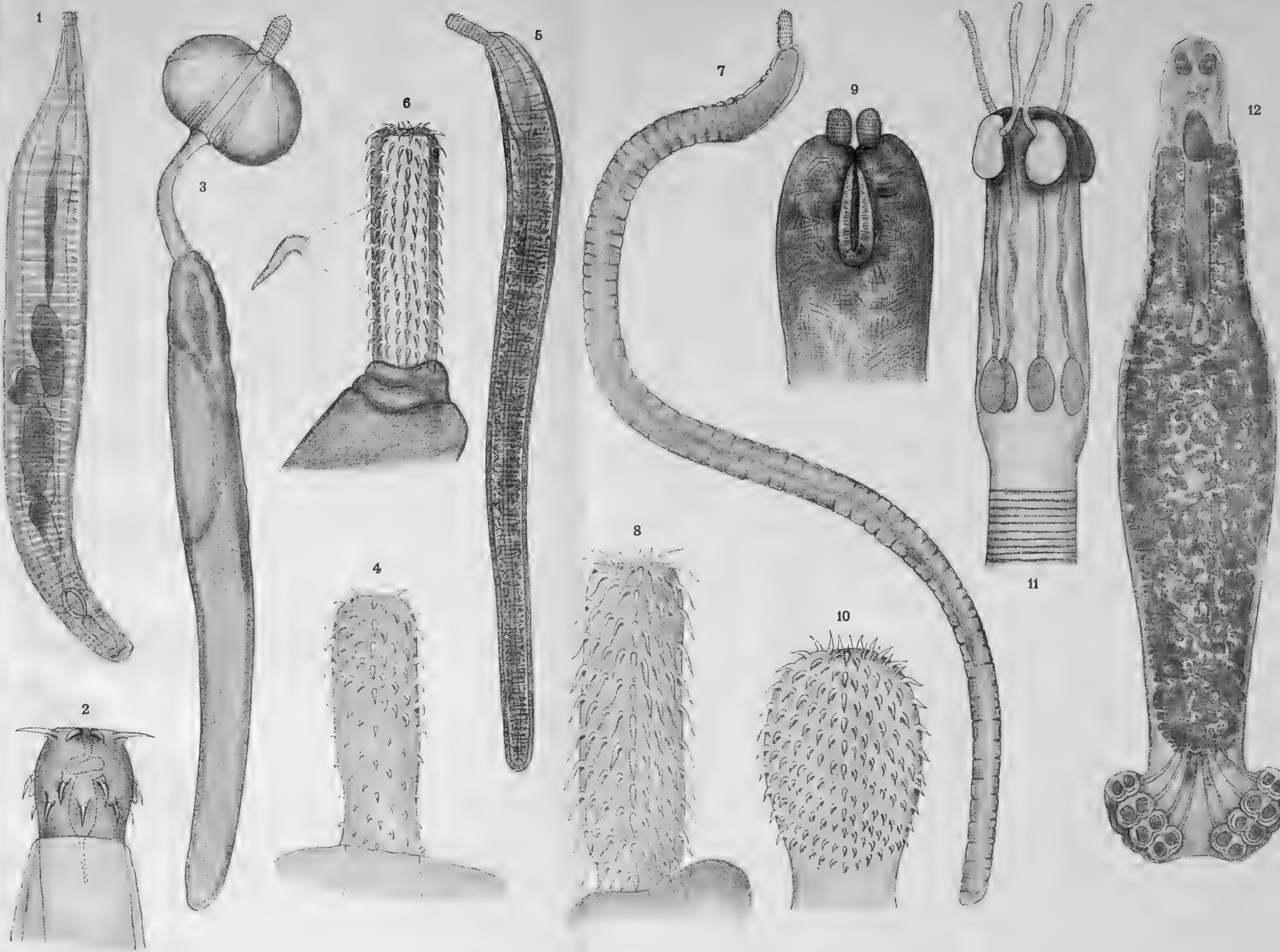
PLATE VII.

Fig. 1. *Diphyllobothrium stemmacephalum*, Cobbold, - about the natural size.
Fig. 2. *Diplobothrium simile*, van Beneden, - slightly enlarged.
Fig. 3. *Distomum cestoides*, van Beneden, - about twice natural size.
Fig. 4. The same, young examples, - - about twice natural size.
Fig. 5. (?) The same, young examples from cysts on the stomach of a Witch Sole, - - - - - twice natural size.
Fig. 6. One of the cysts containing young Distomides, - twice natural size.
Fig. 7. Three-spined Stickleback infested with Cestode worms, - natural size.
Fig. 8. A Stickleback, showing the worms *in situ*, - - natural size.



A. Scott, *del. ad. nat.*

Parasites of Fishes.



A. Scott, *del. ad. nat.*

Parasites of Fishes.

A. SCOTT, *del. ad. nat.*

FIGS. 1–5 and 7–12 PARASITES OF FISHES. FIGS. 6 and 13 a.b.c. PARASITES OF PORPOISE.

A. SCOTT,
Reproduced from Photographs.

FIGS. 1–5 PARASITES OF FISHES. FIGS. 6 and 7 PARASITES OF PORPOISE.

A. SCOTT,
Reproduced from Photographs.

FIG. 1 PARASITE OF PORPOISE. FIGS. 2–7 PARASITES OF FISHES.

IV.—REPORT ON THE OPERATIONS AT THE MARINE FISH HATCHERY, BAY OF NIGG, ABERDEEN, IN 1907. By Dr. T. Wemyss Fulton, F.R.S.E., Scientific Superintendent.

In the season of 1907 the hatching of the eggs of the plaice was continued as in previous years, but owing to the fact that the supply of spawning adults was the lowest since the hatching work was commenced, the number of fertilised eggs collected from the spawning pond and the number of fry obtained and planted in the sea were the lowest for any year. Although the capacity of the pond would allow of considerably over a thousand plaice being retained in it, the number which was available for the supply of fertilised eggs was only 87. The reasons for this are referred to below.

The first eggs were collected on 25th February, and the last collection of a measurable quantity was made on 19th April, although a few eggs were netted at intervals until 16th May. In ordinary seasons, when there was a fairly large number of spawning adults in the pond, the first collections of eggs were obtained usually in the latter part of January and the last in the early part of May, the dates varying a little owing to the temperature and other circumstances. The total number of eggs obtained from the pond in 1907 was estimated at about 1,626,000, whereas in 1906—when the supply of adult plaice was also much below what is necessary—the number was 7,486,000. Of the total, about 40,000 were collected in February, 1,213,000 in March, and 373,000 in April; the largest number were obtained between 16th and 26th March, when about 660,000 were collected. The estimated number of dead eggs which were removed from the hatching apparatus during the season was 345,000, showing a death-rate of about 21 per cent., or about half of what it was in the previous year, when the filtering and water supply arrangements were defective. Included in the measurements of dead eggs are the shells of those which hatched out, so that the number is in reality less than that stated. The estimated number of fry of plaice which were "planted" in the sea was 1,282,000. They were all liberated in the neighbourhood of the hatchery, mostly on 1st April, 12th April, and 25th April, in from $10\frac{1}{2}$ to $11\frac{1}{2}$ fathoms, the surface temperature ranging from 42·8 to 43·5 F.

The fishermen of the northern part of the coast of Aberdeenshire requested that plaice fry from the hatchery should be liberated in their localities as in some former seasons, but owing to the small numbers that were at any one time available it was not thought desirable to incur the expense required in doing so.

During the season there were considerable fluctuations in the temperature of the water in the spawning pond, as may be seen from the table appended. On the 30th December the temperature fell to 29·5 F., and on the next day it was still lower, viz., 29·1 F. In the early part of January it rose, reaching 41 and 42 F. in the period from 12th to 16th, but later in the month and in the first part of February it was very low, falling to 31·3 F. on 6th February and being under 33·4 F. from the 26th January to February 11th. The frost was so severe in the first days of February that the supply of sea water to the tank-house was frozen up. The temperature of the water in the pond fell

again to near the freezing point on 22nd and 23rd February. The temperature of the water in the hatching apparatus between 25th February, when eggs were first obtained, till the close of the season, varied between 33·1 F. (on March 9th) to 52 F. on 15th May. The specific gravity of the water in the spawning pond remained tolerably uniform throughout the hatching season, varying between 27·0 and 27·8.

The number of the eggs of the plaice collected from the spawning pond and the number of fry hatched out and placed in the sea in the various years since the hatchery was established at the Bay of Nigg are as follows:—

	Eggs Collected.	Fry Produced.
1900,	43,290,000	31,305,000
1901,	65,377,000	51,800,000
1902,	72,410,000	55,700,000
1903,	65,940,000	53,600,000
1904,	39,600,000	34,780,000
1905,	40,110,000	24,500,000
1906,	7,486,000	4,406,000
1907,	1,627,000	1,282,000
	335,840,000	257,373,000

The reason for the decline in the hatching work in the last two years was referred to in the last Annual Report, when the operations in 1906 were described. The quantity of fertilised eggs depends upon the number of adult fishes in the spawning pond, and hitherto the stock of spawners was obtained by the use of a trawler which was permitted to fish in the bays of the Moray Firth and in Aberdeen Bay for the purpose of procuring a supply, all the plaice which were suitable for the hatchery being brought ashore in tubs, the remainder of the catch becoming the property of the owner of the trawler as recompense for the use of his vessel. This arrangement was interrupted at the end of 1905, as explained in last Report, and such plaice as have been since obtained for the hatchery have been brought ashore from the Moray Firth by the "Goldseeker," the vessel employed in the international fishery investigations, but the supply has not been adequate for the work. Plaice of the kind required are only to be caught in any quantity on the inshore grounds, where trawling, except for scientific purposes, is prohibited. Under present circumstances it is not possible to get sufficient supplies from the ordinary commercial trawlers working on the offshore grounds in the North Sea. As a rule, the quantity of plaice obtained by them on any single voyage is small, and it would require many expeditions to obtain a sufficient number for the hatchery. The fish obtained in this way would, moreover, have to be purchased at their market value, and the cost could scarcely be borne by the present vote for scientific investigations.

The expense incurred in dealing with a small quantity of eggs is very little less than that of dealing with a large number. At present the cost of the hatching work is very moderate, and is estimated not to exceed about £80 per annum. This is owing to the fact that the work is carried on in conjunction with that of the Marine Laboratory, no additional staff being required, the attendant (Mr. George Walker) being also able to undertake the care of the hatchery, the expenditure on the hatchery representing mainly extra coals, food for the fishes, etc.

TABLE I.—Showing the Daily Progress at the Hatchery, and the Temperature and Specific Gravity of the Water.

Date.		Eggs Collected.	Dead Eggs Removed.	In Pond. Temperature. Cent.	In Pond. Temperature. Fahr.	In Pond. Sp. Gr.	In Hatchery. Temperature. Cent.	In Hatchery. Temperature. Fahr.
1907.								
January	21	...	...	3·0	37·4	27·8	...	...
,,	22	...	...	2·8	37·0	27·8	...	...
,,	23	...	...	3·0	37·4	27·7	...	...
,,	24	...	...	1·6	34·9	27·6	...	...
,,	25	...	...	1·4	34·5	27·6	...	...
,,	26	...	...	0·6	33·1	27·6	...	...
,,	28	...	...	0·8	33·4	27·8	...	...
,,	29	...	...	0·2	32·4	27·8	...	...
,,	30	...	...	0·4	32·7	27·6	...	...
,,	31	...	...	0·0	32·0	27·8	...	...
February	1	...	...	0·0	32·0	27·8	...	...
,,	2	...	...	0·4	32·7	27·8	...	...
,,	4	...	...	0·2	32·4	27·6	...	...
,,	5	...	...	0·2	32·4	27·6	...	...
,,	6	...	...	0·4	31·3	27·6	...	...
,,	7	...	...	0·0	32·0	27·6	...	...
,,	8	...	...	0·8	33·4	27·6	...	...
,,	9	...	...	0·8	33·4	27·6	...	...
,,	11	...	...	1·6	34·9	27·5	...	...
,,	12	...	...	2·0	35·6	27·6	...	...
,,	13	...	...	2·0	35·6	27·6	...	...
,,	14	...	...	1·4	34·5	27·6	...	...
,,	15	...	...	3·2	37·8	27·6	...	...
,,	16	...	...	2·6	36·9	27·5	...	...
,,	18	...	...	3·6	38·5	27·4	...	...
,,	19	...	...	3·2	37·8	27·2	...	...
,,	20	...	...	2·6	36·7	27·6	...	...
,,	21	...	...	1·8	35·2	27·6	...	...
,,	22	...	...	0·6	33·1	27·4	...	...
,,	23	...	...	0·1	32·2	27·2	...	...
,,	24	...	...	1·4	34·5	27·2	...	...
,,	25	A few.	...	3·1	37·6	27·4	...	...
,,	26	...	...	3·4	38·1	27·4	3·6	38·5
,,	27	13,300	...	3·9	39·0	27·2	5·4	41·7
,,	28	26,700	A quantity	4·0	39·2	27·6	5·2	41·4
March	1	20,000	...	4·2	39·6	27·6	5·2	41·4
,,	2	...	...	5·0	41·0	27·6	5·2	41·4
,,	4	20,000	20,000	4·6	40·1	27·4	5·8	42·4
,,	5	...	15,000	4·8	40·6	27·2	5·5	41·9
,,	6	26,700	A quantity	4·2	39·6	27·4	4·4	39·9
,,	7	26,700	10,000	4·6	40·3	27·6	5·2	41·4
,,	8	40,000	...	4·0	39·2	27·4	4·4	39·9
,,	9	40,000	...	2·6	36·7	27·6	0·6	33·1
,,	11	40,000	...	2·8	37·0	27·4	1·2	34·2
,,	12	60,000	...	2·0	35·6	27·4	2·4	36·3
,,	13	40,000	...	2·0	35·6	27·6	2·8	37·0
,,	14	26,700	...	2·6	36·7	27·6	3·0	37·4
,,	15	20,000	...	4·8	40·6	27·6	5·6	42·1
,,	16	60,000	...	4·8	40·6	27·6	4·2	39·6
,,	17	...	...	5·0	41·0	27·6	5·8	42·4
,,	18	100,000	20,000	5·0	41·0	27·4	5·6	42·1
,,	19	120,000	...	4·6	40·3	27·4	4·6	40·1
,,	20	53,300	...	4·6	40·3	27·6	5·0	41·0
,,	21	26,600	80,000	5·2	41·4	27·6	6·0	42·8
,,	22	80,000	...	5·0	41·0	27·6	5·4	41·7
,,	23	80,000	...	5·0	41·0	27·4	4·8	40·6
,,	24	...	...	5·4	41·7	27·4	5·6	42·1

TABLE 1.—*continued.*

Date.		Eggs Collected.	Dead Eggs Removed.	In Pond.			In Hatchery.	
				Temperature.		Sp. Gr.	Temperature.	
				Cent.	Fahr.		Cent.	Fahr.
1907.								
March	25	140,000	...	6·6	43·9	27·4	7·0	44·6
,,	26	60,000	...	7·0	44·6	27·4	6·2	43·2
,,	27	26,600	20,000	7·4	45·3	27·4	7·4	45·3
,,	28	40,000	...	7·6	45·7	27·4	7·2	45·0
,,	29	26,700	...	7·2	44·9	27·4	7·2	45·0
,,	30	40,000	...	7·6	45·7	27·6	6·8	44·2
,,	31	...	...	7·4	45·3	27·2	7·6	45·7
April	1	...	...	7·8	46·0	27·2	7·4	45·3
,,	2	80,000	...	7·0	44·6	27·2	7·4	45·3
,,	3	...	100,000	7·2	45·0	27·4	7·2	45·0
,,	4	100,000	...	7·0	44·6	27·4	7·2	45·0
,,	5	...	...	6·8	44·2	27·2	7·0	44·6
,,	6	80,000	...	6·8	44·2	27·6	6·4	43·5
,,	7	...	...	7·0	44·6	27·4	6·8	44·2
,,	8	40,000	...	6·8	44·2	27·4	6·0	42·8
,,	9	...	...	6·8	44·2	27·4	6·6	43·9
,,	10	26,700	...	7·0	44·6	27·4	6·4	43·5
,,	11	...	...	7·0	44·6	27·6	6·4	43·5
,,	12	20,000	40,000	7·0	44·6	27·2	6·4	43·5
,,	13	...	...	7·4	45·3	27·0	6·8	44·2
,,	14	...	...	8·6	47·5	27·2	7·6	45·7
,,	15	6,700	...	7·6	45·7	27·4	7·8	46·0
,,	16	...	...	7·8	46·0	27·4	8·4	47·1
,,	17	13,300	40,000	7·6	45·7	27·4	7·4	45·3
,,	18	...	...	6·8	44·2	27·0	6·4	43·5
,,	19	6,600	...	6·6	43·9	27·2	6·2	43·2
,,	20	...	...	6·6	43·9	27·2	6·6	43·9
,,	21	...	...	6·8	44·2	27·2	6·6	43·9
,,	22	...	...	7·0	44·6	27·2	6·4	43·5
,,	23	...	...	7·8	46·0	27·4	7·6	45·7
,,	24	...	...	7·0	44·6	27·4	7·2	45·0
,,	25	A few.	...	6·0	42·8	27·4	7·2	45·0
,,	26	...	...	8·4	47·1	27·4	7·6	45·7
,,	27	...	...	8·2	46·8	27·4	6·8	44·2
,,	29	A few.	...	7·4	45·3	27·4	7·4	45·3
,,	30	...	...	7·0	44·6	27·4	7·0	44·6
May	1	...	...	7·8	46·0	27·4	7·4	45·3
,,	2	...	...	7·6	45·7	27·4	7·4	45·3
,,	3	...	...	8·0	46·4	27·4	8·2	46·8
,,	5	...	...	8·4	47·1	27·4	8·4	47·1
,,	7	...	...	8·6	47·5	27·4	8·4	47·1
,,	8	A few.	...	10·0	50·0	27·0	10·2	50·4
,,	9	...	...	10·0	50·0	27·2	10·2	50·4
,,	10	...	...	10·0	50·0	27·2	10·4	50·7
,,	11	...	...	10·2	50·4	27·2	10·0	50·0
,,	13	A few.	...	11·0	51·8	27·0	11·0	51·8
,,	15	.	...	11·0	51·8	27·0	11·2	52·2
,,	16	A few.	...	11·2	52·2	27·0	9·6	49·3
Totals,	-	1,626,600	345,000					

V.—ON THE SPECIFIC CHARACTERS OF THE HADDOCK (*GADUS ÆGLEFINUS*, LINN.), WHITING (*GADUS MERLANGUS*, LINN.); *GADUS POUTASSOU*, RISSO; *GADUS ARGENTEUS*, GUICHENOT; *GADUS SAIDA*, LEPECHIN; *GADUS OGAC*, RICHARDSON; *GADUS NAVAGA*, KÖLREUTER; WITH A KEY TO THE SPECIES OF GADUS FOUND IN NORTHERN WATERS.

By H. CHAS. WILLIAMSON, M.A., D.Sc., F.R.S.E., Marine Laboratory, Aberdeen. (Plates VIII.–XIII.)

CONTENTS.

INTRODUCTION.

This paper continues the research on the classification of the Gadidæ. The two preceding parts were published in the *Twentieth* and *Twenty-fourth Annual Reports of the Fishery Board for Scotland*, Part III., in 1902 and 1906. They dealt with six species, and in the present contribution the remaining seven species are discussed.

I have been indebted to several zoologists for the courteous supply of specimens of the rarer species, and my thanks are specially due to Mr. E. W. L. Holt, Dublin, Drs. Joh. Schmidt and A. C. Johansen, Copenhagen, for examples of *G. poutassou* and *argenteus*; to Professor Brandt, Kiel, Dr. Pappenheim, Berlin, and Professor Vanhöffen, Charlottenburg, for specimens of *G. saida* and the loan of examples of *G. ogac*; and to Dr. Breitfuss, St. Petersburg, for a specimen of *G. saida*. Dr. Hector Jungersen, Copenhagen, also kindly favoured me with the loan of *G. ogac* and *G. navaga*.

The Fishes Examined.

The sizes of the fishes (in cm.) and the localities from which they were obtained were as follows:—

G. æglefinus.—The haddocks were obtained from Scottish waters, and also from Iceland. The Scottish specimens, some of which were fresh, the others preserved in formaline or alcohol, measured—5 at 13, 6 at 14, 6 at 15, 16, 17, 4 at 20, 21, 21, 23, 25, 30, 36, 37, 37, 56, 56, 60, 61. The haddocks from Iceland, which are known in the Aberdeen Fish Market as "Jumbo Haddocks," were examined fresh; they measured 72, 72, 73, 75, 76, 77, 77, 84 cm.

G. merlangus (Diagram).—The whitings were from Scottish waters. Some were fresh, the others preserved. They measured 5, 6, 6, 7, 7, 10, 11, 11, 12, 12, 16, 17, 4 at 18, 20, 20, 21, 21, 22, 23, 23, 24, 24, 35, 36, 46, 48 cm.

G. poutassou (Fig. 4).—Most of the specimens examined had been got by Dr. Fulton during his trawling experiments in the North Sea. One large specimen, 37 cm. long, lent by Mr. Holt, was captured on the West of Ireland, and the poutassou sent by Drs. Schmidt and Johansen were got at 63°21′N. : 21°48′W. in the young-fish trawl, with 100 metres of wire. All were preserved in alcohol or formaline. Their lengths were as follows:—9, 7 at 10, 7 at 11, 6 at 12, 8 at 13, 4 at 14, 6 at 15, 3 at 16, 17, 17, 37 cm.

G. argenteus (Fig. 2).—Some sent by Mr. Holt were got 80 miles W.N.W. of Cleggan, Co. Galway, Ireland, 11th May, 1905; the others, from Drs. Schmidt and Johansen, came from 57°32′N. : 7°E., 31st May, 1907. Two had been captured by Dr. Fulton. All were preserved in alcohol or formaline. They measured 6, 7, 7, 8, 8, 9, 10, 10, 11, 12, 13, 14, 15, 17 cm.

G. saida (Fig. 3).—The specimens of this species were preserved in alcohol. Three were obtained by Professor Vanhöffen at Karajak Greenland; the fourth, from Dr. Breitfuss, was got in the Barents Sea They measured 16, 16, 17, 19 cm.

G. ogac (Fig. 1).—Two specimens, measuring 63 cm. and 33·5 cm. in length, had been obtained in Greenland. The former was captured by Professor Vanhöffen. The latter was lent by Dr. Jungersen.

G. navaga (Fig. 84).—One specimen of this species measuring 17·9 cm. was lent by Dr. Jungersen.

The characters by which the fishes were tested consisted, as in the former portions of the research, of measurements on the fish—Body-Dimensions—and the enumeration of the Vertebræ, Fin-rays, etc.—Enumeration-characters. These characters numbered in all 36. In addition, the the species were compared by the shape of the skull, abdominal cavity, and ovary—Internal characters.

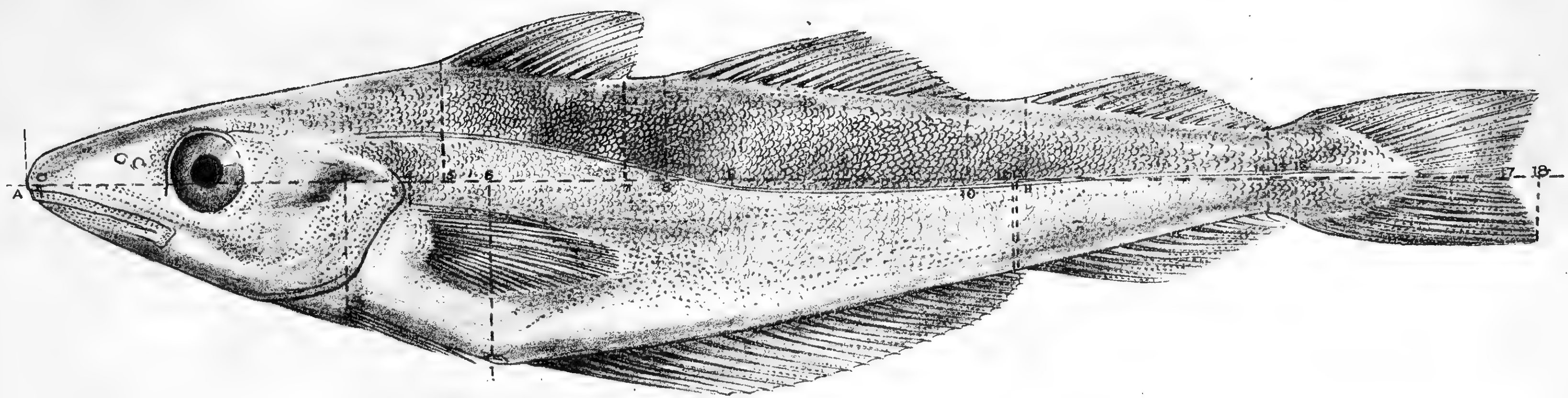
The work has been carried on by the same methods throughout, and with identical characters. Some characters which were adopted in the first two papers have been dropped, and a few characters connected with the abdomen have been introduced. This has necessitated a further examination of certain of the species already treated.

External Characters—The Body-Dimensions.

The body-dimensions which were recorded were of two classes—(*a*) distances of certain points on the body from the anterior end of the fish, and (*b*) girth at three points, and the dimensions of various organs, *e.g.*, the eye and fins.

(*a*) The distances were all measured from the anterior end of the fish when the mouth was closed. In some species this point was the premaxilla, in others the mandible. The distance from the anterior end to each point on the body was taken along the lateral axis. The lateral axis is the line joining the anterior tip of the fish to the middle of tail—Y Z in diagram.

DIAGRAM.



A.H.W. *Gadus Merlangus.* *Nat. Size.*

The measuring board described in "On the Mackerel of the East and West Coasts of Scotland," *Eighteenth Annual Report of the Fishery Board for Scotland*, p. 295, 1900, was used for this part of the research.

The accompanying diagram shows the points on the fish to which the distances were measured.

The point *a* represents the anterior end of the fish (mouth closed).

Distance from the tip of mandible to premaxilla, ...	*a* to 0.
Anterior edge of the orbit (for the length of the snout), ...	*a* to 1.
Base of first ray of ventral fin, ...	*a* to 2.
Opercular cleft, ...	*a* to 3.
Base of first ray of pectoral fin, ...	*a* to 4.
Anus, ...	*a* to 6.
Base of first ray of first dorsal fin, ...	*a* to 5.
" " last " " " " "	*a* to 7.
" " first " " second " "	*a* to 8.
" " last " " " " "	*a* to 10.
End of bend of lateral line, ...	*a* to 9.
Base of first ray of third dorsal fin, ...	*a* to 11.
" " last " " " " "	*a* to 14.
" " " " " first anal "	*a* to 12.
" " first " " second anal "	*a* to 13.
" " last " " " " "	*a* to 15.
Ventral base of tail fin, ...	*a* to 16.
End of middle rays of tail (=Length of Fish), ...	*a* to 17.
Tip of ventral ramus of tail, ...	*a* to 18.

(*b*) *The Girth at the Pectoral Region, at the Anus, and at Root of Tail.*—A thread was passed round the fish at the position and the two ends crossed. A sharp knife was then drawn across the ends, cutting the thread to the size of the girth.

Lengths of the Pectoral, Ventral, and First Dorsal Fins.—In each case the fin was measured from the base of the first ray to the farthest edge of the fin.

Diameter of the Eye.—For this the horizontal diameter of the orbit was taken.

The interorbital space was measured on the top of the head.

The length of the ventral ramus of the tail was measured from the base of the first fin-ray of the caudal fin on the ventral edge to the extreme tip of the ramus.

For the spread of the tail, *i.e.*, the breadth, dorso-ventrally, the tail was not distended to its fullest length; it was simply flattened out.

Length of Barbel.—For the measurement of the lengths of the barbel, fins, and interorbital space, and diameter of the eye, a pair of compasses was employed.

Enumeration-Characters.

Number of rays in each of the dorsal and anal fins.

Internal Characters.

Number of vertebræ. The ural and hypural elements are together counted as one vertebra.

Number of the vertebra bearing the first hæmal arch.

Distance of the first hæmal arch (crown of the arch) from the anterior end of the fish.

Shape of the skull and clavicle.

The colour of the peritoneum.
The number of the lobes of the urinary bladder.
Position of the ureter with respect to the swim-bladder.
Number of pyloric cæca.
Shape of the ovary.
Shape of the abdominal cavity.

Standard—the Length of the Fish.

All the measurements have been represented as percentages of the length of the fish. The length is measured from the anterior end of the fish, mouth closed, to the end of the middle rays of the tail fin.

These have been summarised, and the range of variation with the number of variants for each species is shown in the following table. There are also included the ranges of variation for the Gadids treated in the two previous papers. From the latter the number of variants is omitted, but these can be found in the papers just mentioned. Certain new measurements have been made on the species already treated.

MEASUREMENTS REPRESENTED AS PERCENTAGES OF THE LENGTH OF THE FISH. RANGE OF VARIATION.

	Girth.			Length of Fins.			Eye. Horiz. Diam.	Inter-orbital Space.	Tail.		Length of Barbel.
	Pectoral	At Anus.	Tail.	Pectoral	Ventral.	First Dorsal.			Length Ventral Ramus.	Spread.	
G. callarias	48·3-54·4	44·5-50·2	12-15	11·2-14·2	9·9-11·3	16·5-19	3·3-4·6	5·5-6·6	15·3-18·2	14-17·4	3·7-5
G. ogac	46·4	36·3,48·3 (2)*	10·3, 14 (2)	15·2 (2)	12·6,14·3 (2)	18·2,18·6 (2)	4·8, 5 (2)	7·7, 8 (2)	16, 17·3 (2)	13·3	5, 5·4 (2)
G. navaga	45·8	40·2	13·4	13	10·6	12·8†	5	6·4	..	..	1·9
G. æglefinus (Scotland) 13-37 cm.	45·5-54·5 (31)	44·3-53·4 (31)	12·4-14·8 (31)	13·4-16·1 (31)	11·4-15·6 (31)	16-23·3 (29)	6·1-8 (31)	6·3-7·6 (31)	18·4-21·3 (31)	7·1-13 (24)	·5-1·8 (16)
G. æglefinus (Scotland) 56-61 cm.	..	..	13-14·2 (4)	14·1-15·4 (4)	9·5-10·8 (4)	15·9-18·2 (4)	5·3. 6·2 (2)	6·6-7·1 (3)	..	..	1·4-1·8 (4)
G. æglefinus (Iceland) 72-84 cm.	..	..	14·3-16·2 (4)	14·4-17·4 (8)	9·8-11·6 (8)	16·6-20 (8)	5-5·6 (8)	6·5-8·2 (7)	19·3-19·9 (4)	12·9-16·3 (4)	1·2-1·8 (8)
G. merlangus	38·9-48·4 (25)	40-49·6 (25)	11·9-17·9 (25)	11·9-16·4 (28)	8·8-13 (28)	12·7-17·9 (21)	4·9-8·1 (28)	6-8 (27)	17·3-21·8 (25)	6·8-12·9 (25)	·4-·9 (9)
G. luscus	55-63	55-69	13-15	16-19	14-17	18-24	5-7	5-6	18-20	9·10	6·5, 6·9
G. minutus	46-55	48-58	11-14	15-18	12-16	16-19	6-9	5-6	17-18	5-8	5-6
G. virens	43·9-50·7	47·3-56·7	12·8-15·6	10·9-14·3	5·7-8·6	11·9-14·3	3·3-6	5·5-7·5	16·6-19·3	14·2-19·2	·5-1‡
G. pollachius	42·9-51·9	45·4-59·3	14-17·2	9·9-14·7	4·2-6·6	11·6-14·8	3·5-6·7	4·7-7·3	14·8-19·9	10·5-17·9	..
G. esmarki	37·50	36-52	9-12	16-22	10-16	15·2-16·3	6-9	4-7	17	8-12	2-3
G. argenteus	43·3-56·4 (13)	37·4-52·6 (13)	11·7-15·6 (13)	9·1-11·9 (4)	..	15·1 (1)	9·4-12·4 (14)	5·8-8·3 (14)	..	..	..
G. saida	35·1-43·1 (4)	30·5-35·5 (4)	8-10 (4)	17·8-19·7 (4)	17·4-20·2 (4)	14·2-15·4 (4)	6-6·6 (4)	5·9-6·8 (4)	18·9-20 (4)	9·5-16·6 (4)	·6-·9 (4)
G. poutassou	30-38·3 (31)	27·4-37·6 (29)	9·6-13 (30)	13·2-16·3 (38)	3·7-6·9 (36)	11-11·9 (3)	5·4-7·5 (37)	4·5-6·5 (27)	16·2-19 (28)	6·8·2 (20)	..

* The figures within brackets are the numbers of variants. The numbers of the variants for the species already described have been published in the previous papers.
† The first dorsal fin was a little frayed.
‡ The barbel was found equal to 1 per cent. of the length of the fish in a virens measuring 9·4 cm. in length.

MEASUREMENTS REPRESENTED AS PERCENTAGES OF THE LENGTH OF FISH.
RANGE OF VARIATION—*continued.*

	DISTANCE FROM THE ANTERIOR END OF THE FISH—MOUTH CLOSED.											
	Tip of Mandible.	Tip of Premaxilla.	Orbit.	Ventral Fin.	Opercular Cleft.	Pectoral Fin.	Anus	FIRST DORSAL.		SECOND DORSAL.		End of First Anal.
								Beginning.	End.	Beginning.	End.	
G. callarias ..	·5-1·2	..	7·5-8·9	22-24·6	23·7-26·3	26-28·4	43·9-47·3	28·6-30·9	42-44·2	44-45·8	63·5-66·2	64·6-67·6
G. ogac	·4, 1·2 (2)	..	6·9, 7·4 (2)	17·9, 21 (2)	23·2 (2)	25·3, 27·3 (2)	46·2, 50·6-52 (2)	30·4, 32 (2)	44·7, 46 (2)	46·8, 48·3 (2)	64, 64·7 (2)	65, 67·6 (2)
G. navaga .. .	1·4	..	6·7	18·7	21·2	22·3	39·6	29	40·7	43	59·7	61·4
G. æglefinus (Scot.) 13-37 cm.	1-2·6 (28)	..	6·2-8·7 (30)	18·6-24·6 (30)	23-26·9 (30)	24·7-27·8 (30)	38·4-42 3 (29)	23·9-28·9 (30)	37·4-41·7 (30)	40·3-44·3 (30)	61-65·6 (30)	61·9-66·9 (30)
G. æglefinus (Scot.) 56-61 cm.	·5-1·4 (4)	..	7·4-8 (3)	..	23·7-24·6 (4)	..	41·2, 41·6 (2)	26·1-27·6 (4)	38·2-40·4 (4)	41·6-43·1 (4)	63·4-67·1 (4)	65·1-68 (4)
G. æglefinus (Iceland) 72-84 cm.	·8-2·2 (8)	..	6·6-8 (8)	20-21·9 (4)	22·4-24·9 (8)	24·2-26·4 (8)	39·8-43·9 (7)	24·5-27·3 (8)	36·6-40·3 (8)	40-43·9 (8)	62·8-65·4 (8)	65·5-68 (8)
G. merlangus ..	·3-·9 (13)	..	6-9 (25)	20·5-26 (24)	22·5-26·9 (25)	24-28·5 (25)	29·7-35·8 (24)	27·9-31 (25)	38·9-43 (25)	41·2-46·6 (25)	57-66·4 (25)	60·5-69 (25)
G. luscus	·5	..	5-6	16-18	20-22	21-24	22-29	24-27	36-39	38-41	63-66	61-69
G. minutus ..	·4-·5	..	3-6	17-23	18-21	21-24	30-35	24-27	35-38	37-40	61-65	60-69
G. virens	..	·4-·9	6·7-8·4	21·2-23·3	22·4-24	23·5-25·5	36·4-42·4	30-32·3	41·3-43·7	43·3-46·5	64·6-72·3	61·2-70·4
G. pollachius ..	..	·7-2·7	7·9-10·8	21·6-25	22-25·7	23·4-27·4	33·3-37·3	31·5-35	41·9-45·9	44·3-49	60·5-69·2	63·8-70·8
G. esmarki.. ..	..	·5-1	5-8	18-23	15-22	21-25	32-38	23-29	35-40	37-42	60-64	60-65
G. argenteus ..	..	·9-3·3 (12)	5·8-9·1 (13)	22·4-29·9 (12)	24·4-27·3 (2)	25-31·5 (12)	38·6-43·3 (12)	28·6-33·2 (13)	39·8-44·8 (13)	43·3-49·8 (13)	56·6-63 (13)	57·3-66·4 (13)
G. saida	..	·6-1·2 (4)	6·5-7·4 (4)	21·3-23 (4)	21·4-23 (4)	25-26·3 (4)	41·7-44·7 (4)	28-30·7 (4)	38·7-42 (4)	44·6-46·3 (4)	57·7-60 (4)	60-63·2 (4)
G. poutassou ..	..	·6-2·6 (19)	6·7-8·7 (33)	21·2-25 (34)	21·9-24·9 (28)	23·9-28·4 (36)	29-33·3 (34)	32·8-35·5 (36)	39·9-45·8 (36)	44·3-50·5 (36)	52·5-59·2 (36)	62·8-67·6 (36)

MEASUREMENTS REPRESENTED AS PERCENTAGES OF THE LENGTH OF THE FISH. RANGE OF VARIATION—*continued.*

	DISTANCE FROM THE ANTERIOR END OF FISH—MOUTH CLOSED.							
	THIRD DORSAL.		SECOND ANAL.		TAIL.		Lateral Line—End of Bend.	First Hæmal Arch.
	Beginning	End.	Beginning	End.	Ventral Base.	Tip. Ventral Ramus		
G. callarias	65·8-68·3	78·9-81·7	67-69·7	79·4-81·7	81·9-84·2	97·2-100·5	57·7-64·8	51-52·9
G. ogac	68·2, 69·2 (2)	80·5, 80·9 (2)	68·8, 70·9 (2)	80·8, 81·7 (2)	83·7, 84·1 (2)	100·4, 101 (2)	53·7, 56·9 (2)	..
G. navaga	65·8	79·2	65·3	80·3	83·7	101·6	48	..
G. æglefinus (Scotland) 13-37 cm.	63·2-66·8 (30)	77·5-81·6 (30)	63·8-68·2 (30)	78·2-82·4 (30)	81·8-85 (29)	102-104·4 (31)	67·7-74·4 (19)	51
G. æglefinus (Scotland) 56-61 cm.	65·8-68·1 (4)	80·2-81·6 (4)	66·4-68·6 (4)	81·4-82·7 (4)	83·9-84·5 (4)	101-103·5 (4)	..	..
G. æglefinus (Iceland) 72-84 cm.	64·5-66·9 (8)	79·5-82·2 (8)	66-69·3 (8)	80-82·9 (8)	82·4-84·9 (8)	101·9-104·4 (8)	..	..
G. merlangus	60·5-67·7 (25)	77·7-81·5 (25)	62·3-69 (25)	77·8-82·8 (25)	80·6-84·9 (25)	100·3-102 (27)	61·4-70·7 (22)	..
G. luscus	64-68	77-79	End of 1 A	79-84	81-84	100-101	56-69	44
G. minutus	62-67	79-82	63-68	80-86	83-85	101-106	46-62	..
G. virens	67·9-72·8	81·2-85·4	67·3-73	80·6-85·4	84·6-88·4	102-106·4	47·9-74·7	56·5-61·2
G. pollachius..	67·4-71·6	79·3-84·7	66-72·3	78·2-83·9	83·6-86·8	100-104·3	47·9-63·7	53·3-55
G. esmarki	62-70	78-84	62-67	79-84	84-86	102	48-58	44
G. argenteus	61·6-69·7 (13)	74·9-84·7 (13)	63·2-66·4 (13)	76-86·3 (12)	80·7-89·6 (13)	102-103·3 (3)	64·7	..
G. saida	63·7-65·7 (4)	80·9-82 (4)	63·7-66·8 (4)	81·5-8·3 (4)	83·9-85·7 (4)	104-104·5 (4)	46·2-49·6 61·9-69·4	..
G. poutassou	63·7-70·7 (36)	80-85·5 (36)	64·3-68·9 (36)	86-87·4 (36)	82·9-88·4 (31)	101-106·5 (40)	53·2-85·9 (5)	..

The data set out in these tables are not of direct value from the point of view of specific discrimination. But a detailed examination of them will reveal wherein lie diagnostic characters.

One species may be readily separated on the first examination of the fish by some prominent distinguishing mark, as, for example, the black area on the side of æglefinus. But in another the formulation of a specific description is difficult, not always because the fish resembles its neighbours closely, but owing to the difficulty of expressing the difference. And that obtains, even although the two species may be quite easily separated, when compared side by side. An accurate and detailed description of a single fish will not serve for a specific description in every case. In some instances it might do so, but not in the genus Gadus.

A perfect specific description would be sufficient to enable one to diagnose a fish by itself, without having recourse to direct comparison with another fish. But that is not altogether necessary, since it is usually possible to make use of pictures of some or all of the species. It must, however, be comprehensive enough to admit of the diagnosis of a damaged fish. This can only be assured when the scheme of classification is an extended one, working along various lines, by each of which the species may be reached, or at least found in a reduced group. A fish may be quite normal although deprived of some of its so-called specific characters.

A callarias, 69 cm. in length, was caught near Aberdeen. It had been mutilated. All its fins had been trimmed. The pectoral and ventral fins had been cut off short, movable stumps only being left. All the dorsal and anal fins and the tail fin had been partly cut away. One eye had been destroyed. All the fins had healed and the fish was well nourished. The stomach contained crabs.

The tables given above are useful in showing characters which are hidden when the fish is examined; but they are mainly of service in estimating the exact value of the characters which have otherwise attracted attention. In a group of fishes, as that of the genus Gadus, it is not possible to separate the different members by a simple scheme, because the character which may be of value for separating two species may be quite neutral in the other eleven members of the genus. It is therefore necessary to take the characters of the fish seriatim, making each one a basis for classification. It has usually been thought necessary to subdivide the genus by the test of a single character—for example, by the question of whether the upper or the lower jaw forms the more anterior point of the fish when the mouth is closed. Then in each sub-group the individual members were separated by other characters. Theoretically this is a convenient arrangement, but in practice it is of little value in some cases. For the first selected character may not be readily recognisable in some specimens, and in that case the diagnosis may not be obtained.

A character which is very noticeable in examining different members of the genus Gadus is the varying size of the eye. The size of the eye has been compared by previous authors to the length of the snout and to the length of the barbel. The species may then be grouped according as the eye is less than, equal to, or greater than the snout. An examination of the tables given above will reveal how the species will range themselves under this classification. But while in one species the result will be at once apparent, in another the relationship may be doubtful. That is due to the range of variation in each character. For example, in callarias the diameter of the eye equals 3·3–4·6, while the length of the snout is 7·5–8·9. In this fish the eye is always less than the snout. But in merlangus the relationship is more obscure, the eye measuring 4·9–8·1, while the snout equals 6–9. In such a case it is necessary to refer to the measurements* of each fish, and find out the relationship of the eye and snout in each individual specimen. The result of that enquiry is to show that in merlangus the eye was, in the majority of cases, less than the snout, but it may be equal with it, or it may exceed the snout by a very little. In those fishes in which the lower jaw projects in front of the upper the tables do not show the size of the snout. They give the position of the orbit with reference to the tip of the mandible. The distance between the mandible and the premaxilla must be subtracted from the orbit distance in order to get the length of the snout. In all cases the corroboration of the character must be made on the fishes. This character, the relation of the snout and eye, is a good one for certain fishes, and of less value for others. There is probably hardly a single character or comparison between two characters but may be of more or less value for diagnosis.

There is a certain amount of evidence to indicate a change in the size of certain characters with an increase in the length of the fish. Thus the eye was found to be larger in small æglefinus, virens, pollachius, and to a certain extent merlangus, than in big fishes of these species. In the comparison in length between the pectoral fin and the first dorsal fin of

* The measurements made on the fish are not published here.

pollachius, in one fish measuring 30 cm. in length the former was slightly the greater, while in four specimens measuring 36–93 cm. in length the first dorsal fin was the greater.

The comparative lengths of the paired fins form a specific character of some value. In each species there is a more or less extensive range of variation. In some, *e g.*, virens, the range is short; in the majority it is much greater than in that species.

During the research it was noticed that there might be in a species a character that was specially variable, what might be termed an unstable character. Thus in esmarki the relation between the lengths of the pectoral and first dorsal fins was much more subject to variation than in the other species.

Fin-rays.

The other external characters which have been adopted for classification are the numbers of rays in the unpaired fins. The rays of the paired fins have not been counted except in three species. The number of rays in the ventral fin was found constant at 6. The rays of the pectoral fin varied in luscus and minutus from 18–20, and in esmarki from 19–20. The number of specimens examined were respectively 4, 8, and 5. In the caudal fin 38 and 40 rays were found in luscus, 38 and 39 in minutus, and 40 in esmarki. In this character, 2, 3, and 1 specimens respectively were counted.

The number of rays in each fin is shown for each fish in the following tables :—

[Tables.

THE NUMBER OF VERTEBRÆ AND FIN-RAYS IN GADUS ÆGLEFINUS.

Length. Cm.	Number of Vertebræ.	Vertebra bearing First Hæmal Arch.	Fin-rays.				
			1 D.	2 D.	3 D.	1 A.	2 A.
13	54	23	16	22	21	24	23
13	53	22	16	21	21	24	22
13	55	..	14	22	20	25	21
13	54	23	16	22	21	24	22
13	53	21	13	20	22	24	22
14	53	21	15	22	23	24	25
14	54	..	16	21	21	24	22
14	54	22	14	23	22	24	23
14	54	21	17	21	22	24	22
14	53	22	15	21	22	25	22
14	54	23	15	22	21	24	22
15	54	22	16	22	21	25	22
15	53	21	15	22	20	26	22
15	56	23	15	22	22	25	23
15	53	22	15	20	21	25	23
15	54	22	15	21	19	23	21
15	53	..	14	20	22	24	24
16	53	23	16	22	23	26	23
17	54	21	15	21	21	26	23
20	53	21	16	23	22	23	23
20	..	..	16	23	20	25	22
20	54	21	16	22	20	23	22
20	..	22	14	22	21	24	21
21	54	21	16	23	22	25	23
21	54	22	14	22	20	24	22
23	52	21	15	21	21	26	22
25	54	21	16	22	21	24	25
30	54	22	14	23	22	24	23
36	54	21	16	22	22	24	24
37	54	21	15	25	22	27	24
37	53	22	16	21	21	25	22
56	53	22	16	19	21	24	24
56	55	22	17	22	21	26	23
60	54	21	18	23	21	26	23
61	53	20	14	21	20	25	22
*72	55	22	15	20	21	26	23
*72	54	..	16	22	22	26	22
*73	53	21	15	25	20	27	23
*75	53	21	15	21	21	26	22
*76	54	22	16	21	22	25	21
*77	54	22	15	22	23	24	24
*77	53	21	14	22	20	27	21
*84	55	22	14	22	21	26	24

* Iceland Æglefinus.

THE NUMBER OF VERTEBRÆ AND FIN-RAYS IN GADUS MERLANGUS.

Length. CM.	Number of Vertebræ.	Vertebra bearing First Hæmal Arch.	Fin-rays.				
			1 D.	2 D.	3 D.	1 A.	2 A.
5	54	21	13	21	21	33	24
6	55	..	14	23	21	34	22
6	54	..	12	20	..	31	23
7	54	..	13	19	19	33	22
7	55	21	14	20	21	35	22
10	54	20	13	21	23	35	23
11	54	21	14	21	19	33	21
11	54	22	14	20	21	33	23
12	55	21	14	19	19	34	22
12	55	21	13	21	20	34	22
16	54	20	15	23	21	34	24
17	55	21	13	20	21	32	22
18	54	20	12	20	21	30	23
18	54	23	14	21	21	30	23
18	54	20	13	23	20	34	22
18	55	20	14	20	21	30	23
20	53	20	12	19	20	33	23
20	55	21	15	21	21	35	23
21	55	21	14	22	18	34	20
21	55	21	12	23	19	32	22
22	54	21	13	19	20	29	22
23	55	21	13	23	20	35	24
23	53	22	14	19	19	29	20
24	54	21	15	23	22	37	25
24	54	20	14	23	20	35	24
35	57	23	16	21	23	37	24
36	56	21	14	20	24	37	26
46	55	21	14	23	21	35	24

THE NUMBER OF VERTEBRÆ, FIN-RAYS, AND PYLORIC CÆCA IN GADUS POUTASSOU.

Length. Cm.	Number of Vertebræ.	Vertebra bearing First Hæmal Arch.	Fin-rays.					Number of Pyloric Cæca.
			1 D.	2 D.	3 D.	1 A.	2 A.	
10	57	..	14	13	24	36	26	..
10	57	..	13	12	24	37	27	10
10	56	25	13	12	23	38	26	..
10	57	26	12	11	24	34	24	9
11	58	26	..	..	..	..	..	10
11	57	25	13	14	23	40	27	10
11	58	..	12	13	25	37	26	11
11	57	26	14	13	26	..	24	11
11	57	26	12	12	24	39	25	11
11	58	26	12	11	23	37	25	11
12	57	25	13	12	25	36	26	..
12	58	..	13	12	25	37	25	15
12	58	25	13	11	26	35	25	11
12	58	26	13	13	23	37	25	12
12	58	26	..	..	..	..	..	..
13	58	27	13	14	26	37	26	11
13	55	25	12	13	26	40	27	..
13	57	27	13	15	26	42	27	9
13	57	..	..	..	..	..	..	13
13	58	..	14	11	24	33	26	12
13	57	..	13	12	25	36	27	..
13	57	25	13	12	27	39	28	11
13	58	25	14	13	25	41	27	..
14	58	25	13	11	24	35	26	11
14	57	25	13	11	24	36	26	10
14	57	26	13	12	24	35	26	11
14	58	25	12	13	25	39	26	10
15	57	25	12	12	26	39	27	11
15	57	25	13	13	26	37	27	11
15	58	26	14	12	25	38	27	11
15	57	24	12	11	24	37	25	..
15	57	..	13	10	23	39	28	..
16	57	25	12	13	26	38	27	10
16	57	26	13	13	24	39	26	9
16	57	25	12	13	25	39	28	11
17	56	25	12	11	25	39	26	12
17	58	26	12	12	25	40	27	11
37	..	..	14	12	25	37	26	..

The Number of Vertebræ, Fin-rays, and Pyloric Cæca in Gadus Argenteus.

Length. Cm.	Number of Vertebræ.	Vertebra bearing First Hæmal Arch.	Fin-rays. 1 D.	2 D.	3 D.	1 A.	2 A.	Number of Pyloric Cæca.
6	39	13	12	12	18	17	16	..
7	41	14	11	13	16	15	17	..
7	42	14	11	13	17	18	..	..
8	42	14	10	14	18	17	17	..
8	41	14	12	15	17	17	18	..
9	41	14	9	13	17	17	17	..
10	40	14	10	13	17	15	17	7
10	41	..	11	13	17	17	17	..
11	42	14	11	13	17	17	17	..
12	42	14	12	14	17	18	17	..
13	42	..	11	13	17	17	17	..
14	42	14	12	15	16	15	16	10
15	..	..	12	14	15	18	16	..
17	42	14	12	13	18	18	18	8

Gadus Saida.

16	56	20	11	14	24	17	25	30
16	55	19	12	15	22	20	21	31
17	57	20	15	16	21	22	22	24
19	..	..	14	15	22	16	22	..

Gadus Ogac.

33·5	..	..	17	22	18	21	19	..
63	..	..	17	17	18	21	20	..

Gadus Navaga.

17·9	..	..	14	20	21	24	22	..

In the next table are shown the ranges of variation in the numbers of vertebræ and fin-rays that have been found during this research. The particulars, with the numbers of variants, have been already shown in this and the two previous papers. This table may be used for the specific discrimination by means of the fin-rays.

NUMBER OF VERTEBRÆ AND FIN-RAYS.

RANGE OF VARIATION.

Species.	Number of Vertebræ.	Vertebra bearing the First Hæmal.	Fin-rays.				
			First Dorsal.	Second Dorsal.	Third Dorsal.	First Anal.	Second Anal.
G. callarias . .	51-53	19 (3)	12-15	17-22	18-20	19-24	17-19
,, ogac * . .	...	...	13-17	17-20	17-20	20-23	17-20
,, æglefinus, Scotland . .	52-56	20-23	13-18	19-25	19-23	23-27	21-25
,, æglefinus, Iceland . .	53-55	21 and 22	14-16	20-25	20-23	24-27	21-24
,, navaga † . .	about 58	...	12-14	16-20	20-25	21-24	22-25
,, merlangus. .	53-57	20-23	12-16	19-23	18-24	29-37	20-26
,, luscus . .	48-49	16-17	12-15	21-26	18-22	31-36	18-22
,, minutus . .	48-51	15-18	11-15	20-26	19-23	26-31	20-24
,, virens . .	54-55	24, 25	12-15	19-24	19-24	25-32	20-24
,, pollachius . .	50-55	22, 23	12-14	17-22	17-20	25-34	17-21
,, poutassou . .	55-58	24-27	12-14	10-15	23-27	33-42	24-28
,, esmarki . .	52-55	18-19	14-18	21-29	23-29	24-32	24-30
,, argenteus . .	39-42	13-14	9-12	12-15	15-18	15-18	16-18
,, saida ‡ . .	55-57	19-20	10-14	12-18	18-24	15-22	17-25

* The data furnished for this species by Vanhöffen and Smitt have been included.
† The data furnished by Kölreuter and Smitt for this species have been included.
‡ The data furnished for this species by Günther, Vanhöffen, Smitt, and Jensen have been included.

It is not necessary to discuss the external characters individually, although it may be well to append notes on certain of them. The results of my enquiry into the varied relationship are set out in the key. The intention has been to express the characters on broad lines. Very accurate measurements cannot be adopted in a diagnosis, owing to the fish being liable to damage or distortion. Distortion or injury may render some of the test-characters inapplicable.

GIRTH.—The girth is of considerable importance as indicating the shape of the fish. It is, however, a character that should be measured on fishes in good condition. Where preserved fishes are used only approximate values can be got, and even in fresh material the soft tissues may yield more in one specimen than in another. It would be an advantage to have some characters which would give a definition of the body of the fish, since each species has a general form distinctly different from its neighbours. In this connection a comparison between the species in the dorsal aspect would be of value.

TH SPACE BETWEEN THE SECOND AND THIRD DORSAL FINS.—The wide gap on the dorsal edge between the second and third dorsal fins is a prominent character in poutassou. It is a character that varies

H

much in the genus. In poutassou it reaches its maximum, and in minutus and luscus it sometimes vanishes through the meeting of the two fins. A useful standard with which to compare this space is the length of the base of the second dorsal fin.

The Position of the First Dorsal Fin.—In some species this fin begins nearer the snout than in others. In æglefinus, luscus, minutus, and esmarki, the first dorsal fin is placed farther forward than in the other members of the genus, while in poutassou it occupies the furthest posterior position.

It is an advantage to have the position fixed by comparison with other points on the fish. Thus the beginning of the pectoral fin may be associated with the first dorsal, and the extent of the distance between made a distinguishing character. In some species this character seems to be fairly well fixed, *e.g.*, in æglefinus, while in others, *e.g.*, esmarki and argenteus, it is subject to a considerable range of variation. In several instances, moreover, it has been found that this distance is relatively greater in large fish than in the small specimens of the same species. This distance has been compared to the length of the snout.

Lathral Line.—The lateral line is of specific value, both in its shape and in the form of its scutes. The arctic species saida has a very characteristic lateral line; in it the line forms a bend below the lateral axis, as well as the usual bend above. The line formed by the meeting of the ventral and dorsal muscle segments of the trunk is taken as the lateral axis in this connection. In several species the scutes are noticeable from their wide separation.

Number of Fin-rays —In some cases it would be possible to fix the species by the number of the fin-rays, but there are cases where the fin-ray formulæ of a certain fish might fit into two species. Nevertheless the number of fin-rays forms a very important character.

Internal Characters.—These do not call for special discussion here. They are included in the key.

Discrimination-Characters.

The characters which I have selected, upon which to found a key for the discrimination of the species, are the following:—

The more anteriorly projected jaw, upper or lower.
The position of the anus with reference to the dorsal fins.
The form of the lateral line.
The shape of the tail fin.
The diameter of the orbit compared with the length of the snout.
The presence and size of the barbel.
Comparison in length between the pectoral and ventral fins.
Comparison in length between the pectoral and first dorsal fins.
The position of the first dorsal fin with reference to the pectoral fin.
The relation of the second and third dorsal fins to one another.
The relation of the anal fins to one another.
The relation of the girths at the pectoral and anal regions.
Prominent colour marks.
Separation of the species by length.
The deciduous character of the scales.
The number of rays in the unpaired fins.
The number of vertebræ.
The number of the vertebra bearing the first hæmal arch.
The colour of the inside of the mouth.

The abdominal cavity—the colour of the peritoneum; the first hæmal arch; the form of the abdominal cavity; the shape of the swim-bladder.
The form of the urinary bladder.
The position of the ureter with respect to the swim-bladder.
The shape of the ovary.
The pyloric cæca.
The skeleton. Comparison between the skulls and certain bones of the different species.

KEY.

In cases where measurements are adopted in the key, they are made on similar lines to the measurements described on pages 98 and 99. A pair of compasses will be suitable for this purpose. Distances are measured along the lateral axis.

In the key the æglefinus from Scotland and Iceland are combined.

I. Lower Jaw :—

a. shorter than upper jaw.. .....callarias, ogac, æglefinus, navaga, merlangus, luscus, minutus.
b. of same length as upper jaw ..virens (sometimes in young), minutus (sometimes).
c. projects in front of ,, ,, ...virens, pollachius, poutassou, argenteus, esmarki, saida.

II. Anus :—

a. in front of the first dorsal fin...poutassou.
b. below the beginning of the first dorsal fin........... ..luscus.
c. below the first half of the first dorsal fin. ....luscus, pollachius, merlangus.
d. about the middle of the first dorsal fin ....merlangus, minutus.
e. below the second half of the first dorsal fin ....minutus, virens, esmarki.
f. below the end of the first dorsal fin ....æglefinus, argenteus, saida, navaga.
g. below the interval between the first and second dorsal fins...æglefinus, argenteus, saida, callarias, ogac.
h. below the first half of the second dorsal fin...........callarias, ogac, æglefinus (in two specimens from Iceland the anus was immediately below the beginning of the second dorsal fin).

III. Lateral Line :—

a. straight, white... ....virens (white not always prominent in small specimens).
,, ,, indistinct ....poutassou.
b. curved ....callarias, ogac, navaga, pollachius, minutus.
,, ,, slightly.................æglefinus, merlangus, esmarki, argenteus, saida (see below).
,, curve double...........saida.
c lateral line black (usually jet-black) ....æglefinus.

c. lateral line, posterior part, white ....callarias (the white colour may not be noticeable in small specimens).

„ lateral line yellow or pale in fresh specimens ....merlangus.

Scutes of the Lateral Line.

A basis of classification may be made out of the extent to which the lateral line is continuous or broken up into separate scutes.

The lateral line is a continuous groove ....callarias, ogac, pollachius, merlangus, virens, minutus, æglefinus, luscus. An occasional break occurs at any part in the line. Thus in one callarias the scutes were separate, from the middle of the third dorsal fin backwards.

Lateral line broken up into scutes in its whole length ....saida.

Lateral line broken up into scutes from the beginning of the first dorsal fin backwards...... ....poutassou, argenteus, navaga.

Lateral line broken up into scutes from the end of the first dorsal fin backwards............... ......esmarki.

IV. Tail Fin, Posterior Edge :—

a. straight or convex....... ......callarias.

b. very slightly concave...........callarias (small), luscus.

c. concave........................ } merlangus, minutus, ogac, pollachius,
„ distinctly forked............ } esmarki, argenteus.

d. deeply cleft.......................æglefinus, virens, poutassou, saida.

V. Eye (Horizontal Diameter of the Orbit) :—

a. larger than the length of the snout..........................luscus, minutus, argenteus, esmarki, saida.

b. eye and snout practically equal, being exactly the same size, or one or the other slightly the larger....æglefinus, merlangus, poutassou.

c. eye less than the snout.........callarias, ogac, virens, navaga, pollachius, æglefinus, merlangus.

d. eye oval, long axis vertical...pollachius.

VI. Barbel :—

a. absent............................pollachius, poutassou.

„ „ replaced by two hooks...argenteus.

b. minute..........................merlangus (white), virens (black), saida.

c. small, stumpy...................æglefinus, navaga.

„ „ slender (in length about half the diameter of the eye)........................ .esmarki.

d. long, stout.................... ..callarias, ogac, luscus, minutus, navaga.

VII. LENGTHS OF PECTORAL AND VENTRAL FINS :—

a. ventral fin longer than pectoral fin......................saida.
b. ventral fin equal to pectoral fin............................æglefinus, luscus, minutus.
c. ventral fin less than pectoral fin............................
,, ventral fin greater than half (·7–·9) the length of the pectoral fin...................callarias, ogac, æglefinus, merlangus, luscus, minutus, navaga, esmarki.
,, ventral fin about half (·4–·6) of the pectoral fin...........merlangus, virens, pollachius, esmarki, poutassou.
,, ventral fin less than half the pectoral fin.....................pollachius, poutassou.

VIII. LENGTHS OF THE PECTORAL AND FIRST DORSAL FINS :—

a. first dorsal distinctly greater than the pectoral...........callarias, ogac, æglefinus, argenteus, pollachius
b. first dorsal equal or about equal to the pectoral........merlangus, virens, luscus, minutus, pollachius, navaga (?).
c. distinctly less than the pectoral..........................poutassou, saida, esmarki.

IX. THE POSITION OF THE FIRST DORSAL FIN :—

a. The beginning of the first dorsal fin is just in front of the base of the pectoral fin...æglefinus.
b. The beginning of first dorsal coincides with the base of the pectoral fin...............æglefinus, esmarki.
c. The first dorsal begins close behind the base of the pectoral.......................callarias, æglefinus, merlangus, luscus, minutus, esmarki, argenteus.
d. The distance between the pectoral and first dorsal fins is greater than the length of the snout ....virens, pollachius, poutassou.
,, The distance between the pectoral and first dorsal fins is equal to the length of the snout..........................virens, pollachius, poutassou, minutus, esmarki, saida, navaga.
,, The distance between the pectoral and first dorsal fins is less than the length of the snout.......................callarias, ogac, merlangus, luscus, minutus, virens, pollachius, esmarki, argenteus, saida.

X. The Second and Third Dorsal Fins:—

a. united..........................luscus (sometimes).
b. meet without uniting..........luscus, minutus.
c. The space between the second and third dorsal fins is equal to, or greater than, the length of the base of the second dorsal fin.........poutassou.
,, The space (2 D–3 D) is equal to four-fifths the base of the second dorsal fin........poutassou.
,, The space (2 D–3 D) is equal to half the base of the second dorsal..................pollachius, argenteus.
,, The space (2 D–3 D) is equal to about three-eights of the base of the second dorsal...navaga.
,, The space (2 D–3 D) is equal to one-third or one-fourth of the base of the second dorsal..........................ogac, merlangus, pollachius, esmarki, argenteus, saida.
,, The space (2 D–3 D) is equal to one-fifth of the base of the second dorsal fin.........æglefinus, merlangus, virens, pollachius, esmarki, saida, ogac.
,, The space (2 D–3 D) is less than one-fifth of the base of the second dorsal fin.........callarias, æglefinus, merlangus, virens, pollachius, luscus, minutus, esmarki.

XI. Anal Fins:—

a. united. ....luscus, merlangus (sometimes).
b. First anal has a long base—reaches to second anal without uniting.................. merlangus, minutus, esmarki, poutassou (pollachius, in some the first anal just fails to reach the second anal).
c. There is a gap between the first and second anal fins...callarias, ogac, æglefinus, virens, pollachius (adult), argenteus, saida, navaga.
d. The first anal fin ends in a rounded extremity in callarias, ogac, merlangus, pollachius, poutassou. It tapers away to nothing in virens. They vary a little in different fishes.

XII. Girth:—

a. Girth at pectoral region greater than the girth at anus......callarias, æglefinus, merlangus, poutassou, argenteus, saida.
b. Girth at pectoral region equal to the girth at anus.........æglefinus, merlangus, poutassou, argenteus.

c. Girth at pectoral region less than the girth at anus ...æglefinus, merlangus, luscus, minutus, virens, pollachius, esmarki, poutassou.

d. Girth at root of tail is twice, or more than twice, the interorbital space..........callarias, æglefinus, merlangus, luscus, minutus, virens, pollachius, esmarki, poutassou, argenteus, navaga.

e. Girth at root of tail is over one and a half time, and less than twice, the interorbital space............... æglefinus, merlangus, vireus, minutus, esmarki, poutassou, argenteus, ogac.

f. Girth at root of tail is not more than one and a half time the interorbital space...ogac, saida.

XIII. Prominent Colour Marks in Fresh Condition :—

a. Large black area on the side of the fish, below the first dorsal fin.....................æglefinus.

b. Black patch on the axilla......luscus.

c. Small black patch on the axilla..........................merlangus, minutus, esmarki, saida, (poutassou ?)

d. Upper half of fish dark green...virens, young.

" " " black......... " large.

" " " dark olive...pollachius.

" " " light olive...merlangus.

e. Considerable quantity of amber colouring, scattered or general, on the dorsal half of the body.................. ....callarias, merlangus, pollachius.

f. Silvery cheeks and sides......luscus, minutus, argenteus, and ?

g. General dark-brown colouration of body, dorsum, and ventrum.....................ogac.

XIV. Length of the Fish :—

a. up to 10 inches (25 cm.)......callarias, ogac, æglefinus, merlangus, navaga, luscus, minutus, virens, pollachius, esmarki, poutassou, argenteus, saida.

b. between 10 and 17 inches (25–42 cm.)................callarias, ogac, æglefinus, merlangus, luscus, minutus, virens, pollachius, poutassou, saida, [argenteus ?].

c. over 17 inches (42 cm.)........callarias, ogac, æglefinus, merlangus, virens, pollachius.

XV. Scales very Deciduous........luscus, minutus, argenteus, esmarki ?

XVI. Number of Rays in the Unpaired Fins.

See Table, p. 109.

XVII. Number of Vertebræ.

See Table, p. 109.

XVIII. Number of the Vertebra bearing the First Hæmal Arch

See Table, p. 109.

XIX. The Colour of the Inside of the Mouth :—

The inside of the mouth is black in pollachius.
,, ,, ,, dark, bluish tinge, in virens.
,, ,, ,, brown in ogac.
,, ,, ,, white in callarias, merlangus, poutassou, æglefinus, luscus, minutus, argenteus, esmarki, saida (dull colour in spirit), navaga (yellowish in spirit).

XX. The Abdominal Cavity :—

The Colour of the Peritoneum :

Peritoneum steel-grey colour....callarias.
,, black..................æglefinus, argenteus, poutassou, saida, esmarki.
,, dark ....merlangus, saida, ogac.
,, white ....pollachius, virens.

The First Hæmal Arch.

The number of the vertebra bearing the first hæmal arch varies with the species, as will be seen on reference to the table on page 109.

There is a marked difference in the shape of the first hæmal arch in different species. This is exhibited both in the size of the arch and also in its shape. Drawings of this bone for all the species, with the exception of *G. ogac and G. navaga*, are shown in Plate IV. The posterior side of the arch is represented, the vertebra resting on its anterior disc.

The arch may be round as in pollachius, fig. 39, or nearly round, the condition found in merlangus, fig. 65. The most common shape is that of a broad oval, and that form is found in callarias, fig. 61; virens, fig. 66; minutus, fig. 63; luscus, fig. 67; saida, fig. 59; and esmarki, fig. 64. Æglefinus, fig. 68; poutassou, fig. 57; and argenteus, fig. 58, have a narrow, oval arch.

Æglefinus is readily distinguished from the other species by its characteristic first hæmal arch. It bears two lateral wing-like expansions, fig. 68, which have no counterpart in the other species.

This wing-like expansion is repeated on the second arch, but it has disappeared on the third, a thickened ridge alone representing it. These lateral plates receive the ends of the swim-bladder. Sometimes the expansions are found on three of the 20–23 vertebræ. The first hæmal arch in this species is most commonly found on the 22nd vertebra, but it is also found on the 21st. It may happen that the arch is not complete, one side being short, although the other side may be continued downwards into the hæmal spine. If the hæmal spine is present on an imperfect arch, this is regarded as the first hæmal arch; but if the spine is absent and the arch incomplete, it has been neglected.

Facultative Hæmal Arch.—Occasionally a facultative hæmal arch is formed by the union of the ribs of the vertebra immediately preceding the first hæmal arch. In these cases there is no hæmal spine. Such an

arch may be formed also by the transverse processes being united inferiorly by cartilage in the aponeurosis that lines the bottom of the abdominal cavity. More than one case (æglefinus) was noted where one side only of such an arch was formed: the transverse process on the opposite side did not reach the floor of the abdomen. In minutus the three vertebræ in front of the first hæmal arch formed three facultative arches by means of their ribs, which met inferiorly in the tough fascia. In luscus, two of the ribs from the corresponding region formed almost complete arches.

As a rule the ribs cease on the anterior side of the first hæmal arch, and they are represented behind that point by a film of ligamentous tissue connecting the hæmal arches. In virens, however, a rib was found running obliquely downward from the first to the second hæmal arch.

The first arch is the largest, the succeeding arches becoming smaller, rapidly in some species, more gradually in others. The arches all slope more or less backwards.

The arch bears at its lower end a spine. It is shortest on the first arch, and gradually increases in size in succeeding vertebræ. The hæmal spines are long in æglefinus; in merlangus, poutassou, and saida they are markedly bent backwards from the arches.

The first hæmal spine is usually attached to the aponeurosis that lines the end of the abdominal cavity, and which binds the ends of the interspinous bones. This ligamentous tissue is continued posteriorly, forming the upper edge of the interspinous region. Some of the hæmal spines pass through it into the interspinous region, and are attached directly to the interspinous bones.

The hæmal arch always lodges the caudal artery and the caudal vein. It lodges these alone in saida, fig. 60. The kidney accompanies the blood vessels into the arches in all the other species which I have dissected. The conditions in ogac and navaga were not examined. The swim-bladder enters the hæmal arches in most of the species, *e.g.*, virens, fig. 74; pollachius, fig. 72; merlangus, fig. 62; luscus, fig. 71; minutus, fig. 80; poutassou, fig. 70; esmarki, fig. 75. In callarias, fig. 91, and æglefinus, fig. 81, the end of the swim-bladder reaches to the second hæmal arch. The swim-bladder does not enter the hæmal arches in argenteus, fig. 69, and saida, fig. 60.

The extent to which the swim-bladder and the kidney enter the hæmal arches may be here summarised :—

Callarias.—The swim-bladder is continued back to the second and third hæmal arch. It is bound tightly to the first and second arches; it is constricted much by the first arch.

Æglefinus.—The swim-bladder ends at the second hæmal arch, to which it is bound firmly below.

Merlangus.—The swim-bladder is continued backwards to the 8th or 9th hæmal arch.

Virens.—The swim-bladder extends back to the 4th, 5th, or 6th hæmal arch, tapering to a fine point. It is bound to the first hæmal arch.

Pollachius.—The swim-bladder extends posteriorly to the 10th or 11th hæmal arch.

Luscus.—The swim-bladder goes back to the 13th arch; the kidney seems to end at the 6th arch.

Minutus.—The swim-bladder ends at the 10th arch; the kidney was very small and not noticeable on the outside of the arches.

Poutassou.—The swim-bladder extends to the 6th arch.

Esmarki.—The swim-bladder ends at the 9th arch.

Argenteus.—The swim-bladder ends at the vertebra in front of the first hæmal arch. The first and second arches are filled with the kidney, which ends at the 3rd arch.

Saida.—The swim-bladder ends a little in front of the first hæmal arch; the kidney ends at the first hæmal arch.

The Form of the Abdominal Cavity.—In some cases the first hæmal spine ends the abdominal cavity, *e.g.*, callarias, fig. 91; æglefinus, fig. 81; virens, fig. 74; poutassou, fig. 70. In other species the cavity is continued posterior to that point, either above it, that is, into the hæmal arches, or below, into a sub-hæmal cavity formed between the hæmal spines and the interspinous bones of the first anal fin.

Of the former condition the following species are examples:—Pollachius, fig. 72; luscus, fig. 71; minutus, fig. 80; esmarki, fig. 75; argenteus, fig. 69. In these fishes the liver, ovary, and gut may extend into the hæmal arches. The fishes which have the sub-hæmal extension of the abdominal cavity are merlangus, fig. 62, and saida, fig. 60. None of the movable abdominal organs enter the hæmal arches, but they have room below for expansion. Poutassou, in which the hæmal spines are markedly bent backwards, fig. 70, might be regarded as having a slight sub-hæmal extension.

In many of these fishes the interspinous region of the first anal has a long stretch which is not directly supported by the vertebral column.

The peritoneum is loosely attached to the hind end of the abdominal cavity.

In esmarki a white matter of a soft and fatty appearance was found in the hæmal arches.

In saida the abdominal cavity is lofty, the vertebral column coming very near the dorsal edge.

The Shape of the Swim-bladder.—In the Gadids the swim-bladder is usually large. The anterior end is sometimes furnished with horn-like prolongations.

In callarias these are long and they have a spiral form. They pass round the head kidney and lie on top of it, between the branches of the vagus nerve and the muscles at the top of the clavicle.

Pollachius, fig. 85; merlangus, fig. 95; and virens, have two short horns. In one virens the horns were absent.

According to Kölreuter, the swim-bladder in navaga has two horns.

XXI. Urinary Bladder:—

The urinary bladder has two lobes............................callarias, ogac, æglefinus, minutus, esmarki, argenteus, (saida). In argenteus the lobes are short. In saida one or two small swellings were noticed on the urinary bladder; in one example, however, none were seen.

The urinary bladder has no lobe...................................merlangus, luscus, virens, pollachius, poutassou.

XXII. The Position of the Ureter with respect to the Swim-bladder.

Species.	Number of Cases on Right Side of Swim-bladder.	Median in Position.	Number of Cases on Left Side of Swim-bladder.
Callarias . .	5	...	5
Æglefinus .	9	...	3
Merlangus .	12	...	3
Luscus . .	4	...	7
Minutus . .	25	...	14
Virens . .	6	...	6
Pollachius .	14	...	10
Esmarki . .	32	...	21
Pontasson .	7	...	8
Argenteus .	...	5	...
Saida . .	...	2	...

In certain of the species there appeared to be some indication that a sexual difference might be found in the character. Although the ureter was found in each sex on both sides of the swim-bladder, still there seemed to be a tendency for the majority of cases in each sex to be on one side.

In callarias the ureter leaves the kidney at the first hæmal arch; it pierces an extension of the wall of the swim-bladder.

In virens the ureter was found to leave the kidney at the second vertebra in front of the first hæmal arch.

In pollachius it left at the junction of the first and second vertebræ in front of the first hæmal arch.

In argenteus the ureter was median just behind the swim-bladder, which ended one vertebra in front of the first hæmal arch.

In saida the ureter issued behind the end of the swim-bladder, *i.e.*, at the first hæmal arch.

XXIII. The Ovary.

There is much difference between the species in the shape of the ovary. This organ varies in the comparative lengths of the anterior and posterior lobes. In some the posterior lobes of the ovary are fused in part or in their whole extent.

Then in side view the ovary may be distinctly triangular in shape, exhibiting a great increase in dorso-ventral thickness at the oviduct, or the ovary may show very little taper from the middle to either end.

For this purpose large roes of each species have been examined. They are ovaries containing yolked eggs. The ovary of virens was, however, unripe, and for esmarki a small unripe ovary probably lately spent has been drawn. I did not have an ovary of poutassou sufficiently large.

In side view the following are markedly triangular in shape:—Pollachius, fig. 94; virens, fig. 13; luscus, fig. 73; minutus, fig. 77; esmarki, fig. 97.

The two hind lobes are short in callarias, fig. 90; aeglefinus, fig. 87; esmarki, fig. 97.

The two hind lobes are about the same length as the anterior lobes—merlangus, fig. 79; saida, fig. 78.

The two hind lobes are fused together—virens, argenteus, fig. 92; ogac.

The two hind lobes are fused in part of their extent—pollachius, fig. 96. The two hind lobes are fused up to the point A.

In the other species the hind lobes are bound together by mesentery—callarias, fig. 90; æglefinus, fig. 87; saida, fig. 78; merlangus, fig. 79; esmarki, fig. 97; luscus.

The ovary is pigmented black—ogac, fig. 76.

The oviduct in merlangus, callarias, and luscus is long.

The oviduct is short in æglefinus.

Saida.—Vanhöffen found in the ovary of this form 12,700 eggs measuring ·5 mm. in diameter. The fish was obtained in December at Karajak. In another fish obtained in the same month the yolked eggs in the preserved fish are yellow, resembling the egg of *Sebastes marinus*; they measured ·7 mm. in diameter.

Merlangus.—A full roe of a fish 30 cm. long contained the shrunken remains of old eggs in the beginning of the oviduct. The posterior lobes of this ovary were longer than the anterior lobes. The full roe is of a deep orange colour.

Æglefinus.—The ripe roe is of a light orange colour; it is thick dorso-ventrally.

Poutassou.—In the small specimens the ovary showed as two little lobes close to the rectum. Fishes up to 17 cm. in length had a minute ovary. In the last case the ovary contained clear eggs measuring ·05 mm. in diameter.

XXIV. The Pyloric Cæca.

The cæca are small, very numerous, closely arranged in a mat—æglefinus, ogac, callarias, virens, pollachius.

Merlangus.—There is a large mass of cæca numbering from 33 to 90.

Poutassou.—The cæca were from 9 to 15 in number.

Argenteus.—The cæca were from 7 to 10 in number.

Saida.—The cæca were 24, 30, and 31 in number.

XXV. The Skeleton.

The skulls might be classified according to their length, but data are not at present available which would give the maximum size of the skull for each species. Any skull measuring 14 cm. in length may belong to the following species:—Callarias, ogac, virens, pollachius. The skulls of luscus, minutus, esmarki, argenteus, saida, probably never reach 10 cm. in length. The skull of whiting does reach and probably exceeds 10 cm. in length. One poutassou which I received on loan from Mr. Holt measured 37·9 cm. in length, and the skull probably measured between 8 and 9 cm. in length. The two specimens of this species described by Vinciguerra measured 35 cm. in length.

The Skulls, etc.—Callarias, virens, pollachius, Plates IV.–XI., *Twentieth Annual Report*; luscus, minutus, esmarki, Plate X., *Twenty-fourth Annual Report*; æglefinus, Plate II.; merlangus, ogac, poutassou, argenteus, saida, Plate III.

The differences between the skulls of the various species cannot be

readily reduced to words, and comparison must be made either on the skulls themselves or by means of drawings.

There is a certain number of characters by which the skulls may be roughly separated into groups.

SIDE VIEW.—The first of these is—the shape of the ventral edge of the skull; that is, formed by the vomer, parasphenoid, and basi-occipital bones.

If the skull be laid resting on its ventral edge on a flat surface, so that the vomer, from which the teeth have been removed, is directly on the surface, it will be found that the next part of the edge to touch the surface will be:—(*a*) the basi-occipital, or (*b*) the hind half of the parasphenoid, or (*c*) the swollen opistholics projecting below the ventral edge.

To (*a*) belong callarias and ogac (fig. 15).

To (*b*) belong æglefinus, (fig. 11), merlangus (fig. 18), virens, pollachius, luscus, minutus, esmarki, poutassou (fig. 24), argenteus (fig. 26).

To (*c*) belongs saida (fig. 25).

The largest number of species, therefore, belong to division (*b*). In these skulls the basi-occipital is raised above the surface on which the skull rests. The extent to which it rises varies among the species, from the very slight elevation in merlangus to the very high upward bend in argenteus.

The opisthotics which form the cavities containing the otoliths are very varying in the part they play in the shape of the skull, and the differences may be referred to the following divisions, which are to be noted in a side view of the skull:—

The opisthotics do not extend down to the ventral edge of the skull in callarias, virens, pollachius.

They extend down closely to the ventral edge—æglefinus.

They extend down to the ventral edge of the skull—æglefinus, merlangus, luscus, esmarki, poutassou, [ogac ?].

They extend downwards beyond the parasphenoid; they project ventrally, in saida, argenteus.

A marked difference is found in the shape of the inter-orbital arch, the base of which is furnished by the parasphenoid, while its rim is formed by the pre-frontal, frontal, orbito-sphenoid, and pro-otic.

The arch is less than a semi-circle, *i.e.*, the length of its base is more than twice its height, in callarias, ogac, virens, pollachius, merlangus, saida, poutassou.

The arch is nearly a semi-circle in æglefinus and luscus.

The arch is a semi-circle in esmarki, minutus, argenteus.

The ethmoid slopes backwards much in virens, pollachius, saida, poutassou, argenteus, esmarki.

The anterior edge of the ethmoid is nearly vertical in callarias, ogac, æglefinus, merlangus, luscus, minutus.

There is a prominent notch in the front edge of the ethmoid in luscus, minutus, esmarki, argenteus.

A small notch is sometimes made out, but is sometimes absent—llarias, ogac, virens, pollachius.

The notch is absent—saida, poutassou.

The occipital spine rises high on the frontal bone in ogac, virens, llachius, merlangus, minutus, esmarki, argenteus, æglefinus, and luscus. is very high in the two last named.

The occipital spine does not rise off the frontal bone, but begins as a

thin verticle lamina on the parietal in saida; on the frontal it is merely a ridge. It rises, but is very low, on the frontal in callarias.

The hind end of the squamosal is very broad, its upper and lower edges are almost parallel, in æglefinus. The two edges approach one another rapidly as they proceed posteriorly in callarias, virens, pollachius, merlangus.

View from Above.

The shape of the frontal is of some importance. It tapers much at its anterior extremity in callarias, virens.

It is rounded in front in æglefinus (fig. 9), pollachius, merlangus (fig. 16), luscus, minutus, esmarki.

The middle foramina of the frontal are well separated from the anterior opening of the supra-orbital groove in callarias, ogac (fig. 19), æglefinus, virens, pollachius.

The foramina and the openings come close together in luscus, minutus, merlangus, poutassou (fig. 14), argenteus (fig. 20), saida (fig 13). They come very close together in the last species.

There are characteristic differences in the shape of the pre-frontals. As a rule their lateral edges slope backwards and outwards, *e.g.*, in callarias, ogac, æglefinus, virens, pollachius, poutassou.

In the following the pre-frontals project broadly from the side of the skull:—Luscus, minutus, esmarki, saida, argenteus. In argenteus the pre-frontals project anteriorly as broad plates (fig. 20).

The foramen of the *nervus lateralis* (*for.*, fig. 9) is associated with a projecting plate (*prc.*, *ib.*, fig. 16) of the parietal.

The plate covers the foramen: the plate is very large in pollachius, luscus.

The plate covers the foramen: the plate is a prominent process in callarias, merlangus.

The plate covers the foramen: the plate is long and comparatively narrow in minutus, esmarki, poutassou.

The plate covers the foramen: the plate is present as a very small ridge in saida.

The foramen is in front of (fig. 9) or on top of the process (fig. 19), which is very small, in æglefinus, ogac.

The ridge is absent in argenteus. The parietal is largely cartilaginous, and the foramen seems to pierce the parietal on top and anterior to the position usually occupied by the ridge in other Gadids.

In minutus the process was sometimes pierced on top by a foramen: the foramen of the *nervus lateralis* was covered by the process.

View from Below.

The opisthotics are swollen, rounded, with the parasphenoid depressed between them, in poutassou, saida, argenteus, minutus, esmarki.

The groove in the hind part of the parasphenoid, *i.e.*, between the articulations of that bone with the opisthotics, is very slight in virens, ogac.

The groove is well marked in æglefinus, merlangus, luscus, minutus, saida, esmarki, poutassou, argenteus.

The hind part of the parasphenoid is flat, or slightly convex, in callarias, pollachius.

Callarias and Ogac.

The skull of ogac which I was able to examine, was damaged in the occipital spine, squamosals, opisthotics, and ex-occipitals, but it was,

nevertheless, sufficiently complete to show that the skull of this species differs distinctly from that of callarias.

Seen from above the frontal of ogac is a shorter and broader bone than that of callarias. In the latter it tapers much anteriorly. This relation accounts for the broad interorbital measurement on the head of ogac.

The foramen of the *nervus lateralis* is covered in callarias by the process of the parietal. In ogac the foramen is above and in front of the process.

The opisthotics in ogac appear to extend down to the vertical line of the skull: they do not in callarias.

The vomer seems to be rather more pointed (view from above) in callarias than in ogac.

The occipital spine in ogac rises high on the frontal, whereas in callarias it is simply a ridge.

The skull of ogac is, I consider, on the whole shorter than that of callarias.

Diagnostic Value of other Bones.

Clavicle.—The clavicle of æglefinus is a characteristically solid bone (fig. 7). The post-clavicle of the same species is of a similar build (fig. 6). The clavicle and post-clavicle of merlangus are shown in figs. 22 and 28.

The skull and other head bones of æglefinus are well ossified.

Otoliths.—The otoliths of the Gadidæ and other fishes have been treated lately by Dr T. Scott. I have therefore included here only five of the species, viz.:—Poutassou (fig. 21), argenteus (fig. 29), saida (fig. 30), ogac (fig. 23, after Vanhöffen), minutus (fig. 56).

In the case of the three species first discussed in this research, viz., callarias, virens, and pollachius, the comparison between them was carried out on all the bones of the head, and the result was to show that almost every bone had a greater or less specific character. The jaw bones are of much value in this respect. I have not continued this extended comparison of the skeleton. I publish here, however, drawings of an additional part of the skeleton of pollachius which, so far as I am aware, has not been published. The bones of the head of pollachius were figured in my paper in the *Twentieth Annual Report of the Fishery Board for Scotland*, Part III.

On the Diagnosis of Isolated Bones and Otoliths.

The presence of certain Gadoids in the stomachs of fishes and other animals has been detected by the otoliths which had resisted disintegration. An example of this is given by Scott, who found a large number of the earstones of merlangus in the stomach of a porpoise.

Jensen found in the bottom-deposits taken from the Polar Deep between Iceland and Jan Meyan, large numbers of the otoliths of poutassou, some of saida, and one each of callarias and virens.

There are also single bones, the specific identity of which can be recognised at once. For example, several of the bones of æglefinus are of this character, the clavicle and post-temporal being massive in comparison with those of other species.

It is, however, an advantage to have several bones of the fish upon which to work out the diagnosis.

I have on several occasions found on the shore of a small fresh-water

lake near Aberdeen, viz., Loch Loirston, little collections of bones. They were uninjured, but the skull bones were disarticulated. They had evidently been disgorged by some bird, probably a heron or a gull. They were sometimes stuck together in a bolus, which indicated, no doubt, that they had been disgorged a short time before. A similar bolus consisting of the husks of grain was noticed also.

The bones consist of the bones of the head, and one or two vertebræ. The vertebral column is absent.

One lot of bones consisted of those of merlangus. They were accompanied by whole and crushed shells of *Purpura lapillus*; the latter were stained purple. The bones were readily diagnosed by the otoliths, and by the fact that the following bones agreed with those of a type specimen, viz., dentary, mandible, and premaxilla.

The premaxilla was big in comparison with the other bones accompanying it. It was distinctly a Gadid bone. It had two rows of tooth-sockets, the outer very large, the inner very small. The latter tended to doubling near the head of the bone. The sockets extended over the bone almost to the tip. It was necessary to compare this bone with known premaxillæ of nearly the same size. It was compared in turn with the premaxillæ of callarias, pollachius, virens, æglefinus, luscus, minutus, merlangus. It agreed exactly with the latter.

One difficulty arises from the fact that the number of rows of teeth may vary with age. Thus in a pollachius measuring 36 cm. in length there were three rows of teeth on the broader part of the premaxilla, whereas as many as six rows could be made out on a big specimen, *e.g.*, 85 cm. long. Again, a callarias measuring 23·5 cm. had three or four rows of small teeth on the premaxilla, next the head of the bone, while an example 92 cm. long had six rows at least of small teeth in the corresponding place.

A second group of bones was found to consist of the bones of more than one æglefinus. The fishes were probably about 30 cm. in length. The characteristic heavy clavicle, supra-clavicle, and post-temporal were present. The premaxilla agreed with that bone taken from an æglefinus. The otoliths were present, but were not relied upon for diagnosis.

The Rib (Pleurapophysis) in Pollachius.

There are no ribs attached to the first and second vertebræ. The third, fourth, and fifth vertebræ bear stout ribs that have truncated ends. The first of these ribs (fig. 44) is the heaviest, the others getting gradually lighter. There are no transverse processes (parapophyses) on the third and fourth vertebræ, and the head of the rib fits into a hollow in the side of the centrum. The fifth vertebræ has a little transverse process, and as one proceeds along the vertebral column this process grows steadily bigger. The rib is anteriorly attached to the under surface of the parapophysis, but as the latter gets larger the rib is attached to the hind edge of its extremity. The ribs of the sixth* and seventh vertebræ are thinner and end in sharp points (*vide* fig. 45). Fig. 53 shows a rib situated further back on the vertebral column, and fig. 46 shows the shape of the head in different ribs.

The epipleural spines are attached to the ribs towards the head of the same.

* In one case the rib of the sixth vertebræ had a truncated end.

Distribution of the Gadidæ.

Hoek gives the distribution of the Gadidæ in northern waters in his catalogue of fishes of the North of Europe.

The Young Stages of the genus Gadus.

The young stages have been described by many authors. The subject has been comprehensively dealt with lately by Schmidt. He has described many stages of the following species:—Callarias, virens, pollachius, æglefinus, merlangus, luscus, minutus, poutassou, argenteus, esmarki.

The Stomach and the Gut.

The stomach is capable of great distension and extension. This is specially noticeable in virens. When gorged the stomach may extend well back into the hind abdomen. When the reproductive organs are large, however, they tend to prevent the full distension of the stomach.

The gut forms a loop in the hind part of the abdominal cavity. It goes backwards on the right side of the body and returns on the same side. The end of the loop is free in the cavity. Sometimes the loop goes round the end of the abdomen and extends forward for a little way on the left side (fig. 98). This condition was noted in some specimens of the following species:—Callarias, æglefinus, esmarki.

The Mesentery in Virens.

The mesentery is continuous with the peritoneum lining the posterior end of the abdominal cavity. It divides the hind abdomen longitudinally into two from the floor to the roof, binding the ureter to the hind lobes of the ovary and the latter to the roof of the cavity.

Proceeding anteriorly, it splits into two, giving a mesentery to each of the free anterior lobes of the ovary. Each lobe is thus supported separately to the roof of the abdomen. In front of the anus the mesentery is attached to the rectum at the beginning of the ovarian lobes, but anterior to this point it has no connection to the ventral surface. The spleen is supported by a median mesentery, and is often found lying between the lobes of the ovary.

Notes on the Species.

Callarias.—A prominent character in this fish is the broad fan-shaped tail fin. Its hind edge is convex. In the small cod the tail is slightly different in shape. In two specimens, 23 cm. and 38 cm. respectively, the hind edge was straight across. In two others, 25 cm. and 28 cm., there was a slight concavity in the hind edge.

The ureter left the kidney at the transverse process of the vertebra in front of the first hæmal arch.

The cod sometimes exhibits a small angle in the anterior edge of the orbit.

Æglefinus.—This species has a large eye and a small mouth.

In the large haddock, *e.g.*, from Iceland, the scales are large and the skin is tough and hard.

The barbel is stumpy, with a bulbous base.

The first dorsal fin has a characteristic shape in this species. It is

prolonged to an acute point. The longest ray was in 19 cases the second in one case it was the third ray. In one instance the second and third rays were of equal length. The fins have in the fresh condition a narrow white border.

Very little difference was noticed between the big Iceland haddocks and the haddocks obtained near the Scottish coasts. The eye of the large haddock is smaller in proportion than that of the small fish. Thus in the haddocks from 13–37 cm., the eye ranged from 6 to 8 per cent. of the length, whereas in the Iceland specimens, 72–84 cm. long, the eyes only reached 5–5·4 per cent. of the length. The eyes of the large Scottish haddocks, 56–61 cm. in length, occupied an intermediate position, viz., 5·3–6·2 per cent. of the length. The ventral fin was shorter in the large Scottish and Iceland specimens, viz., 9·8–10·8 and 9·8–11·6 per cent., than in the smaller Scottish fishes, where it measured 11·4–15·6 per cent. of the length. The Iceland fishes had a thicker root of tail and a greater spread of tail than the Scottish fish, measuring up to 37 cm. in length. In the other characters the fishes from the two regions were in agreement. The slight divergences noticed above may be simply differences due to age.

Merlangus.—Several writers have described merlangus as a Gadid in which there is no barbel. The barbel is, however, present. Steindacher found it in all the examples examined by him (Vinciguerra). I have found it in each specimen in which it was looked for. In a merlangus measuring 22 cm. in length the barbel measured 2 mm. Six large merlangus measuring 43–49 cm. were examined, and a very small white soft barbel was made out under the lens. It could just be detected in some cases, since it is so soft that it clings to the adjacent skin.

The ventral fin has a filamentous tip.

The anal fins sometimes unite (*vide* fig. 83). The last ray of the first anal fin is distinguished from the first ray of the second anal fin by the fact that the tip of the former is free, whereas the tip of the latter is buried in the tough skin which covers the front edge of the fin.

The caudal fin has a black margin. In fishes about 18 cm. long it is somewhat fanshaped. When the mouth is closed the upper jaw projects in front of the mandible, but when the mouth is open the mandible extends to the level of the premaxilla.

The longest ray of the first dorsal fin was noted in 16 cases. The third was the longest in 13 cases; in one fish it was the second. The third and fourth were equal in one instance, and in another the third, fourth, and fifth were equal. The unpaired fins have a narrow white margin.

Virens.—The lower jaw projects very much in large fishes. In the small fish of this species this character is not so prominent, and inexact examination may lead to the conclusion that the two jaws are of equal length. A number of small virens were examined to test this relationship. In 18 fishes measuring 20 to 30 cm. the lower jaw projected in front of the upper, in some by a little, in others more distinctly. One measuring 26 cm. in length appeared at first sight to have the two jaws of equal length, but examination showed that the lower just showed in front of the upper when the fish, with the mouth closed, was viewed from the dorsal side.

The eye in some virens is oval, with the long diameter vertical. A small angle in the anterior edge of the orbit is sometimes noticeable.

The little barbel is black.

Pollachius.—The eye in large pollachius (*e.g.*, 90 cm.) is distinctly oval in shape, both as regards the orbit and the lens also. The long axis of the oval was vertical

The ureter was found in one specimen to start from the kidney at the junction between the first and second vertebræ in front of the first hæmal arch.

Poutassou.—This species has no barbel. When the skin was removed from the dentaries, two small knobs were noticed in that region.

The tongue is spear-shaped. The wide gap between the second and third dorsal fins is characteristic.

The lateral line is nearly straight; it is inconspicuous in some specimens.

In one formaline specimen the skin was covered with minute black spots. In another there was an extensive dark axillary region. The snout was black. There appeared to be also a black pigment spot on the middle rays of the tail fin.

The black peritoneum sometimes shines through the abdominal wall in preserved specimens.

Gadus (*Gadiculus*) *argenteus.*—Guichenot separated this form from Gadus on account of the supposed absence of vomerine teeth in the former. Günther found, however, that the vomer does bear teeth. A skull measuring 3.6 cm. in length, from one of the present specimens, had very small teeth in the vomer.

It is a fragile form, and the specimens were much frayed. The skin had, as a rule, disappeared from the top of the head, exposing the cavities in the frontal bone, and the fin-rays were usually snapped off. There are therefore no data to show the relation in length between the pectoral and ventral fins. The pectoral fin was measured in four cases, but in no example was the ventral fin whole.

A double hook is present on the dentaries, one hook on each bone, in the region where the barbel is found in the Gadidæ.

The ureter leaves the kidney medianly just behind the end of the swim-bladder.

G. saida, Lepechin.—Vanhöffen obtained this species in quantity at Karajak, Greenland. He describes it as follows:—"In the upper half of the body it was of a brownish-grey colour, while the under-body had a silvery appearance. The skin was dotted with very small black pigment cells, which were at one time expanded into stellate chromatophores, at another were contracted to dots. The fins also showed a more or less broad dusky border, from which the black dusting extends along the fin-rays to their bases. The scales were circular and very small." The largest example found by Vanhöffen measured 22 cm. Jensen obtained two specimens measuring 25 and 26·7 cm. in length respectively. "Fabricius records one of a length of 35·6 cm."

Vanhöffen institutes a comparison between saida and pollachius, virens and minutus. "Minutus resembles saida in its colour, even to the indication of a black spot on the base of the pectoral fin. The main distinguishing features of saida are the small number of rays on the first anal fin and the narrower root to the tail. Moreover, the form of the otolith seems characteristic. Saida is distributed over the whole North Polar Sea, in East and West Greenland, Spitzbergen, Barents Sea, Behring Sea, and on the coasts of Labrador." It is also found at Iceland (Schmidt).

The barbel is very small.

The membrane of the fins is thin, and the fin-rays are weak.

The tail is broad dorso-ventrally.

The head has great depth; the mouth is very large.

The lateral line is made out with difficulty by means of the small detached scutes. It follows a sinuous course; starting above the oper-

cular cleft, it passes backwards in a gentle curve to cross the lateral axis about the beginning of the second dorsal fin. It continues its course below the lateral axis either in a single curve or in several smaller curves, to rise again to the axis near the beginning of the third dorsal fin, and to run straight backwards to the tail. The part below the lateral axis sometimes varies on the two sides of the fish.

The skin of the preserved fish had a golden sheen.

The ureter left the kidney at the first hæmal arch. It was in the mesentery between the two hind lobes of the testis.

The ovary was yellow in colour.

The testes in one specimen measuring 16·8 cm. were very large; they filled up practically the whole of the abdominal cavity (fig. 88 T).

Jensen obtained small specimens of this species in Greenland. Two post-larval fishes measured 13·5 and 16 mm. in length. They were captured in August. A quantity of fry measuring 45–74 mm. was obtained in the same month. One, 45 mm. long, "is pigmented on back and flanks with dark cross-formed or stellate chromatophores. In the larger young ones the dark chromatophores are sometimes massed in some places towards the back, and produce an intimation of transverse bands; the distal margins of the dorsal fins, and partly also of the anal fins, are frequently strongly pigmented."

Gadus ogac, Richardson. Fig. 1. Plate I. Fig. 13a.—Vanhöffen had the opportunity of examining this species in the fresh condition in Greenland. He discusses it as follows:—

"*Gadus ovac*, Reinhardt, is only a dark-coloured variety of *Gadus morrhua*, occurring on the coasts of Greenland. Both of these species are got there. The near relationship of ovac and morrhua is seen in the number of the fin-rays and in the structure of the otoliths (fig. 23), as well as in the body measurements, which in some respects approach æglefinus. According to Dresel, ovac and morrhua from the Greenland and American coasts differ, in addition to colour, in the following respects:—In ovac the tail is narrower, the eye is larger, the inter-orbital space more prominent, the barbel longer, the ventral fin is placed further forward, and the pectoral fin is longer than in morrhua. Lütken distinguished them by the following characters:—Ovac has a plumper form, thicker head, and broader forehead. The upper jaw does not extend so far forward, and it reaches further back than in morrhua. The unpaired fins are higher and more rounded in ovac. The lateral line is not distinct, and the body is of a dark colour without clear spots." Vanhöffen maintained that of these characters only the following remained of moment, viz., the greater breadth of the forehead, the length of the barbel, and the different colour of the body. He dismissed the character founded on the length of the barbel, and pointed out that the form of the head changes in fishes with age, or season, or habits, while colour was generally recognised as one of the most uncertain characters. Summing up, he could not agree with Lütken, who insists on ovac as a separate species; but from the present state of knowledge, must agree with Günther in regarding it as a variety of *G. morrhua*. Ovac has been recorded from the West Coast of Greenland, from Iceland, and Scotland (Günther).

I have had the privilege of examining one of Vanhöffen's specimens, and also one from the Copenhagen Museum. I am of the opinion that ogac is a good species. It is not possible to get a satisfactory specific description from two specimens, and I am not, therefore, inclined to put too much emphasis on the body characters which have been already selected, although I am disposed to regard them as valid.

There are two characters which have not so far been mentioned. One of these is the shape of the skull (figs. 15 and 19 and page 122), which is very distinct from that of callarias, and the second is the presence of black pigment on the external wall of the ovary (fig. 76, *ov.*), and also inside that organ. I have not, so far, noticed black pigment in the ovary of any other Gadid. This ovary of ogac contained small yolked eggs measuring ·3 mm. in diameter, large yolked eggs ·65 mm. in diameter, and clear eggs ·05–·2 mm. in diameter.

As Vanhöffen pointed out, ogac comes very near callarias in the number of fin-rays in the unpaired fins, but a similar relationship exists between other Gadids, *e.g.*, virens and pollachius, luscus and minutus. The following are certain points which were prominent in this fish (figs. 21 and 13a):—The barbel is long, stout on one example. The lateral line has a bend that is not very pronounced; it meets the lateral axis about the first half of the second dorsal. The skin is of a uniform dark brown all over. The peritoneum is very dark. There is an external anal tube (fig. 13a) in one example. The ureter opens to the exterior by a small median aperture close behind the wide genital opening. The tail fin is slightly concave on its hind edge. The abdominal cavity extends back to about the middle of the first anal fin (fig. 76). The piebald colour of the ovary is noteworthy (fig. 76). The inside of the mouth is brown-coloured.

The specimen belonging to the Copenhagen Museum was much smaller. It measured 33·5 cm. in length. It is shown reduced in Plate VII. The hind margin of the tail is distinctly concave, with the rami of the tail rounded. The forehead is flattish. The barbel is long, and not very stout. There is no distinct anal tube, although there is a raised border round the anus, and there is a fairly long genital tube projecting. The lower jaw is very little short of the upper when the mouth is closed.

The fish is of a laminarian colour all over; the abdomen is of a lighter shade of the same colour. The scales are brownish-tinted, transparent, except at the exposed part, where there is a patch of dark brown pigment. The rings of growth on the scales are well marked. The lateral line is continuous, except from the middle of the third dorsal backwards, where the scutes are separate. Both ogac and callarias have the sensory processes, possessed by other Gadids, on the inside of both lips. The pits on the skin of the mandible are common to other species of Gadus in addition to ogac and callarias. No difference was made out in the teeth between the two species.

Gadus navaga is a small species. Its specific characters are given by Günther as follows:—

Barbel small; shorter than the eye, the diameter of which is somewhat less than the width of the inter-orbital space and one-half of the length of the snout. The snout is sub-conical, obtuse, with the upper jaw the longer. The height of the body is less than the length of the head, which is one-fourth of the total (without caudal). The vent is situated vertically below the origin of the second dorsal. Tail very slender, fins separated by interspaces from one another. Caudal fin truncated. Colour, brownish with reticulated dark lines on the back.

Size—Seven to nine inches long—White Sea.

Kölreuter says that the colour is brown over the dorsum without spots. The swim-bladder has two horns.

The specimen kindly lent by Dr. Jungersen was obtained in Greenland (fig. 84). In general colouring it was not unlike a small cod that had been preserved in alcohol. It has a little stumpy barbel with a fine tip, nearly resembling that of æglefinus. The tail fin was damaged, one

ramus only being present. Smitt says that the concavity in the hin edge of the tail fin is greater in this species than in ogac.

There is a small external genital papilla. The head resembles that of merlangus. The growth rings on the scales are well marked. The lateral line is composed of separate scutes behind the beginning of the second dorsal fin.

The Specific Identity of a Fish.

The specific identity is not merely the possession of certain external characters, or a matter of certain distances measured on the surface of the body. It extends through the whole of the organism, exhibiting itself in the skeleton, the abdominal cavity and its organs, and in the appearance, edible quality, and flavour of the flesh. The habits of each species, when they are thoroughly known, will probably be found to be very distinct, the mode of life, food, etc., all serving to distinguish one species from another. In a genus all the species will overlap in their modes of life, just as they do in their bodily characters, but in the aggregate of their habits they will be as clearly identified as in their external form and appearance.

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EXPLANATION OF THE LETTERS USED IN THE PLATES

a.—Anus.
At.—Atlas Vertebra.
1 a.—First anal fin.
2 a.—Second anal fin.
b Oc.—Basi-occipital.
bl.—Bladder.
br.—Broken edge of bone (figs. 15 and 19).
c.—Centrum of Vertrebra.
cæ.—Cæca.
Cl.—Clavicle.
E.—Ethmoid.
e Oc.—Ex-occipital.
F.—Frontal.
f.—Pseudo hæmal arch (fig. 74).
for.—Foramen.
ft.—Fibrous tissue.
g.—Gut.

EXPLANATION OF THE LETTERS USED IN THE PLATES—*Continusd.*

g. ap.—Genital aperture.
g. p.—Genital papilla.
h k.—Head kidney.
hp.—Hæmapophysis (side of hæmal arch).
hs.—Hæmal spine.
1 h.—First hæmal arch.
in. sp.—Interspinous bones
k.—Kidney.
l.—Liver.
m.—Muscle.
me.—Mesentery.
np.—Neurapophysis.
ns.—Neural spine.
Oc. Sp.—Occipital spine.
op. O.—Opisthotic.
Or. S.—Orbito-sphenoid.
Ot.—Otolith.
ov.—Ovary, oviduct.
P.—Parietal.
par. Oc.—Par-occipital.
pl.—Pleurapophysis.
pp.—Parapophysis (transverse process of Vertebra).
prc.—Process (of a bone).
pr. F.—Pre-frontal.
pr. O.—Pro-otic.
p. S.—Para-sphenoid.
pt. Cl.—Post-clavicle.
pt. F.—Post-frontal.
rct.—Rectum.
s. Oc.—Supra-occipital.
s. Or.—Anterior opening of supra-orbital groove.
Sq.—Squamosal.
st.—Stomach.
sw. bl.—Swim-bladder.
t.—Testis.
ur.—Ureter, urinary.
V.—Vomer.
Vert.—Vertebra.
Zyp.—Zygapophysis.

EXPLANATION OF PLATES.

DIAGRAM.

Gadus merlangus, to show Measurement—Characters. *See* p. 99.

PLATE VIII.

FIG. 1. *Gadus ogac.*
,, 3. ,, *saida.* $\times \frac{5}{6}$
,, 2. ,, *argenteus.* $\times \frac{5}{6}$ Imperfect specimen.
,, 4. ,, *poutassou*, reduced. Natural size was 16 cm. in length.

PLATE IX.

FIG. 6. Post-clavicle of *G. æglefinus.* Iceland. *Nat. size.*
,, 7. Clavicle of *G. æglefinus.* Iceland. *Nat. size.*
,, 8. Skull, view from below, *G. æglefinus.* Iceland. *Nat. size.*
,, 9. ,, ,, ,, above, ,, ,, ,,
,, 10. ,, ,, ,, behind, ,, ,, ,,
,, 11. ,, ,, ,, side, ,, ,, ,,

PLATE X.

FIG. 12. Skull of *G. saida*, from above. *Nat. size.*
,, 13. Ovary of *G. virens*, 92 cm. long. September 1908. $\times \frac{1}{2}$. Eggs measure ·22 mm.
,, 13A. *G. ogac.* Greenland. $\times \frac{1}{3}$. Anal region to show anal tube (*a*).
,, 14. Skull of *G. poutassou*, 17 cm. long, from above. *Nat. size.*
,, 15. ,, *G. ogac*, from the side. *Nat. size.*
,, 16. ,, *G. merlangus*, from above. *Nat. size.*
,, 17. ,, ,, ,, behind. ,,
,, 18. ,, ,, ,, the side. ,,
,, 19. ,, *G. ogac*, from above. *Nat. size.*
,, 20. ,, *G. argenteus*, from above. *Nat. size.*
,, 21. Otolith of *G. poutassou*, two views. Natural size. Fish 16 cm. total length.
,, 22. Post-clavicle of *G. merlangus.* *Nat. size.*
,, 23. Otolith, two sides, *G. ovac*, 67 cm. long. *Nat. size.* After Vanhöffen.
,, 24. Skull of *G. poutassou*, from side. *Nat. size.*
,, 25. ,, *G. saida*, from side. *Nat. size.*
,, 26. ,, *G. argenteus*, 14·6 cm., from side. *Nat. size,*
,, 27. ,, *G. merlangus*, from below. *Nat. size.*

FIG. 28. Clavicle of *G. merlangus*. *Nat. size.*
,, 29. Otolith of *G. argenteus*, right side. *Nat. size.* Sharp end posterior. *o* outer side, *i* inner side. There is a ridge along the centre.
,, 30. Otolith of *G. saida*. *Nat. size.*
,, 31. Vomer of *G. poutassou*, from in front.

PLATE XI.

FIGS. 32–55 are of *Gadus pollachius*, 87·8 cm. long.
FIG. 32. Atlas vertebra seen from the side next the skull. *Nat. size.* *x*—part that articulates with the basioccipital; *y*—part that articulates with the ex-occipital.
,, 33. Eleventh vertebra, posterior end. *Nat. size.* The small processes, *prc.*, on the edge of the centrum unite eventually with the posterior element of the parapophysis (transverse process). They are present on the vertebra bearing the first hæmal arch (viz., the twenty-second vertebra), but have disappeared on the twenty-fifth vertebra.
,, 34. The first eleven vertebræ. × ½ *c*—centrum ; *pp*—parapophysis.
,, 35. Pectoral fin-ray. *Nat. size.*
,, 36. First dorsal fin-ray seen from the posterior side. *Nat. size.* *h*—small hemispherical articular processes between the two half-rays.
,, 37. Seventh ray of first dorsal fin. *Nat. size.* Side view.
,, 38. Vertebræ, 12 to 26, × ½. *Zyp*—zygapophysis.
,, 39. Twenty-second vertebra, bearing the first hæmal arch. *Nat. size.* Posterior surface. *Hp*—hæmapophysis.
,, 40. Vertebræ, 27–53, × ½.
,, 41. Interspinous bone of third dorsal fin. *Nat. size.* *Pt*—protuberance.
,, 42. First eleven vertebræ, ventral view. × ½.
FIG. 43. Fifth vertebra, showing the end next the skull. *Nat. size.* *ns*—neural spine ; *np*—neurapophysis ; *pp*—parapophysis ; *pl*—pleurapophysis.
,, 44. First rib (*i.e.*, attached to the third vertebra). *Nat. size.*
,, 45. Rib attached to the sixth vertebra (?) *Nat. size.*
,, 46. Heads of ribs. Enlarged a little.
,, 47. Caudal fin-ray. *Nat. size.*
,, 48. ,, ,, ,, Left side ; *lh*—left half ; *rh*—right half.
,, 49. ,, ,, dorsal view. *Nat. size.*
,, 50. Half of a caudal fin-ray, showing the surface that is in contact with the other half-ray. *Nat. size.* *u*—unsegmented strip ; *s*—segmented intermediate portion.
,, 51. Base of caudal fin-rays. Ventral view. *Nat. size.*
,, 52. Basi-branchials, seen from above.
,, 53. One of the ribs attached to the seventh to twenty-first vertebræ. *Nat. size.*
,, 54. Eleventh vertebra, seen from above. *Nat. size.* The neurapophysis is formed in part of cancellous tissue. The pores are large and perforate the bone.
,, 55. Interspinous bones of the first dorsal fin.
,, 56. Otolith of *G. minutus*, 23 cm. long. *Nat. size.*
,, 57. First hæmal arch of *G. poutassou*, 13·7 cm. long. *Nat. size.*
,, 58. ,, ,, ,, *G. argenteus*. *Nat size.*
,, 59. ,, ,, ,, *G. saida*. *Nat. size.*
,, 60. Hind abdominal cavity of *G. saida*. *Nat. size.*
,, 61. First hæmal arch of *G. callarias*, 38·8 cm. *Nat. size.*
,, 62. Hind abdominal cavity of *G. merlangus*, 38·5 cm.
,, 63. First hæmal arch of *G. minutus*, 21·7 cm. *Nat. size.*
,, 64. ,, ,, ,, *G. esmarki*, 19·5 cm. ,,
,, 65. ,, ,, ,, *G. merlangus*, 38·5 cm. ,,
,, 66. ,, ,, ,, *G. virens*, 53 cm. ,,
,, 67. ,, ,, ,, *G. luscus*, 27·5 cm. ,,
,, 68. ,, ,, ,, *G. æglefinus*, 36 cm. ,,

PLATE XII.

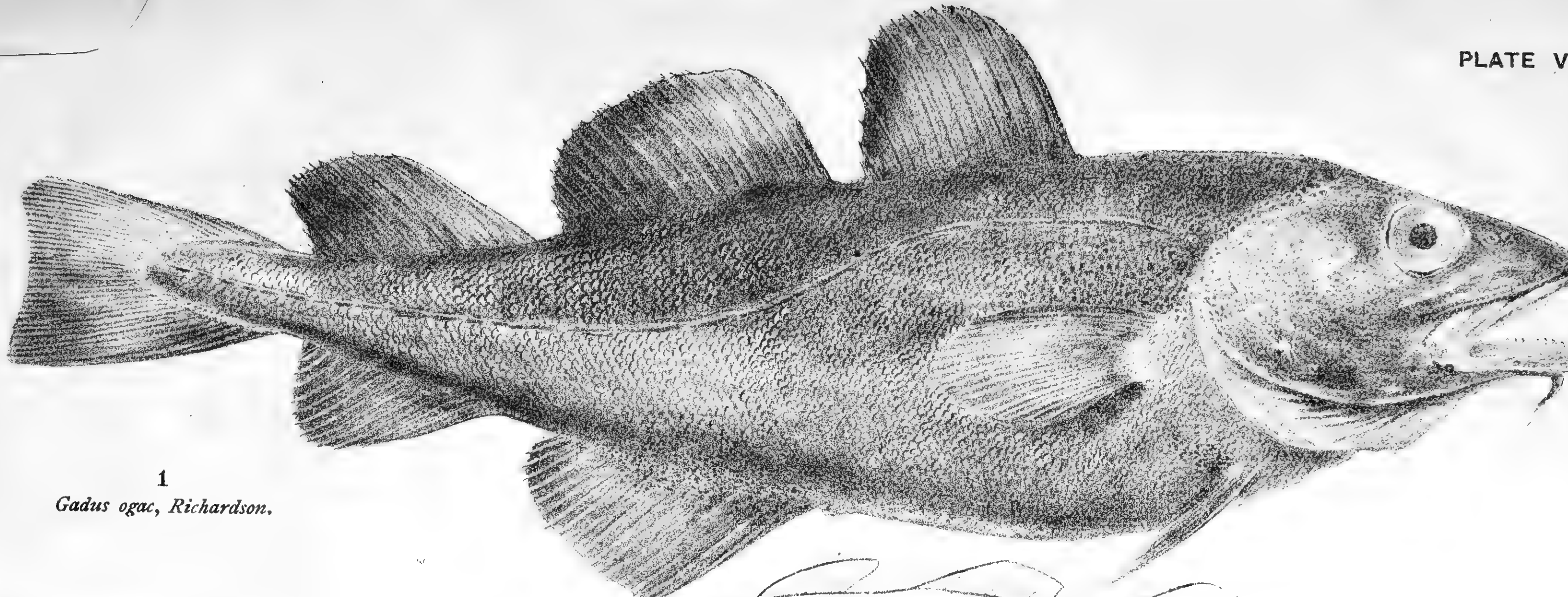
FIG. 69. Hind abdominal cavity of *G. argenteus*. *About nat. size.*
,, 70. ,, ,, ,, *G. poutassou*, 13·7 cm. long. Reduced.
,, 71. Abdominal cavity of *G. luscus*, 27·5 cm. long. Reduced.
,, 72. ,, ,, *G. pollachius*, 93 cm. long. Reduced. The dotted line indicates the course of the ureter on the right side of the body.

FIG. 73. Ovary of *G. luscus*, 27·5 cm. long. Reduced.
,, 74. Abdominal cavity of *G. virens*, 55·4 cm. long. Reduced.
,, 75. ,, ,, *G. esmarki*, 15·7 cm. long. ,,
,, 76. ,, ,, *G. ogac.* × $\frac{1}{3}$.
,, 77. Ovary of *G. minutus*. Reduced.
,, 78. ,, *G. saida*, 17·5 cm. long. *Nat. size.*
,, 79. ,, *G. merlangus*. Reduced.
,, 80. Hind abdominal cavity of *G. minutus*, 26·5 cm. *Nat. size.*
,, 81. ,, ,, ,, *G. æglefinus*, 36 cm.
,, 82. Ovary of *G. merlangus*, 36·4 cm. long. Side view.
,, 83. Junction of first and second anal fins of *G. merlangus*, 36·4 cm. long.

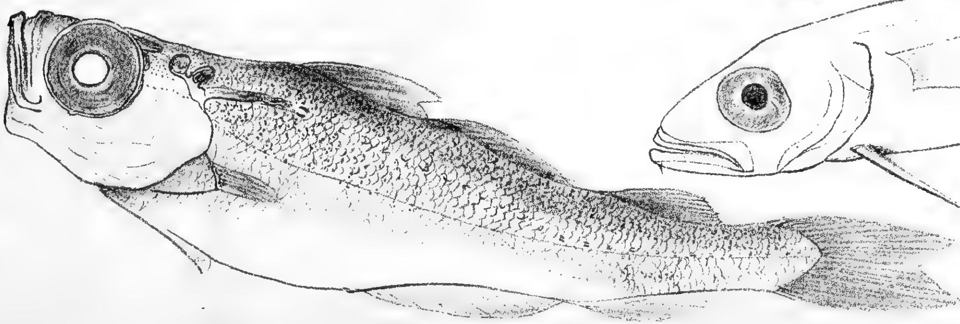
PLATE XIII.

FIG. 84. *G. navaga. Nat. size.*
,, 85. Anterior end of swim-bladder of *G. pollachius*, 50·5 cm. long.
,, 86. Abdomen opened to show ovary, etc., of *G. esmarki.*
,, 87. Ovary of *G. æglefinus*. View from above.
,, 88. Abdomen of *G. saida*, opened to show large testis—*t*. *Nat. size.*
,, 89. Loop of gut at end of abdomen of *G. pollachius*, 76 cm. long.
,, 90. Ovary of *G. callarias*. × $\frac{1}{4}$.
,, 91. Hind abdominal cavity of *G. callarias*, 69 cm. long. Reduced.
,, 92. Ovary of *G. argenteus*, 17·4 cm. long. *About nat. size.*
,, 93. Anterior end of the swim-bladder of *G. callarias.*
,, 94. Ovary of *G. pollachius*, 80 cm. long. Side view. × about $\frac{1}{2}$.
,, 95. Anterior end of the swim-bladder of *G. merlangus.*
,, 96. Ovary of *G. pollachius*. Same as Fig. 94. View from below.
,, 97. Ovary of *G. esmarki*, 19·5 cm. long. *About nat. size.*

PLATE VIII.



1
Gadus ogac, Richardson.



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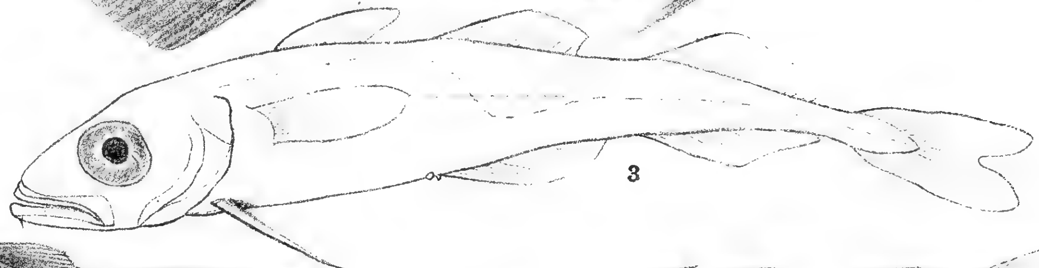


3

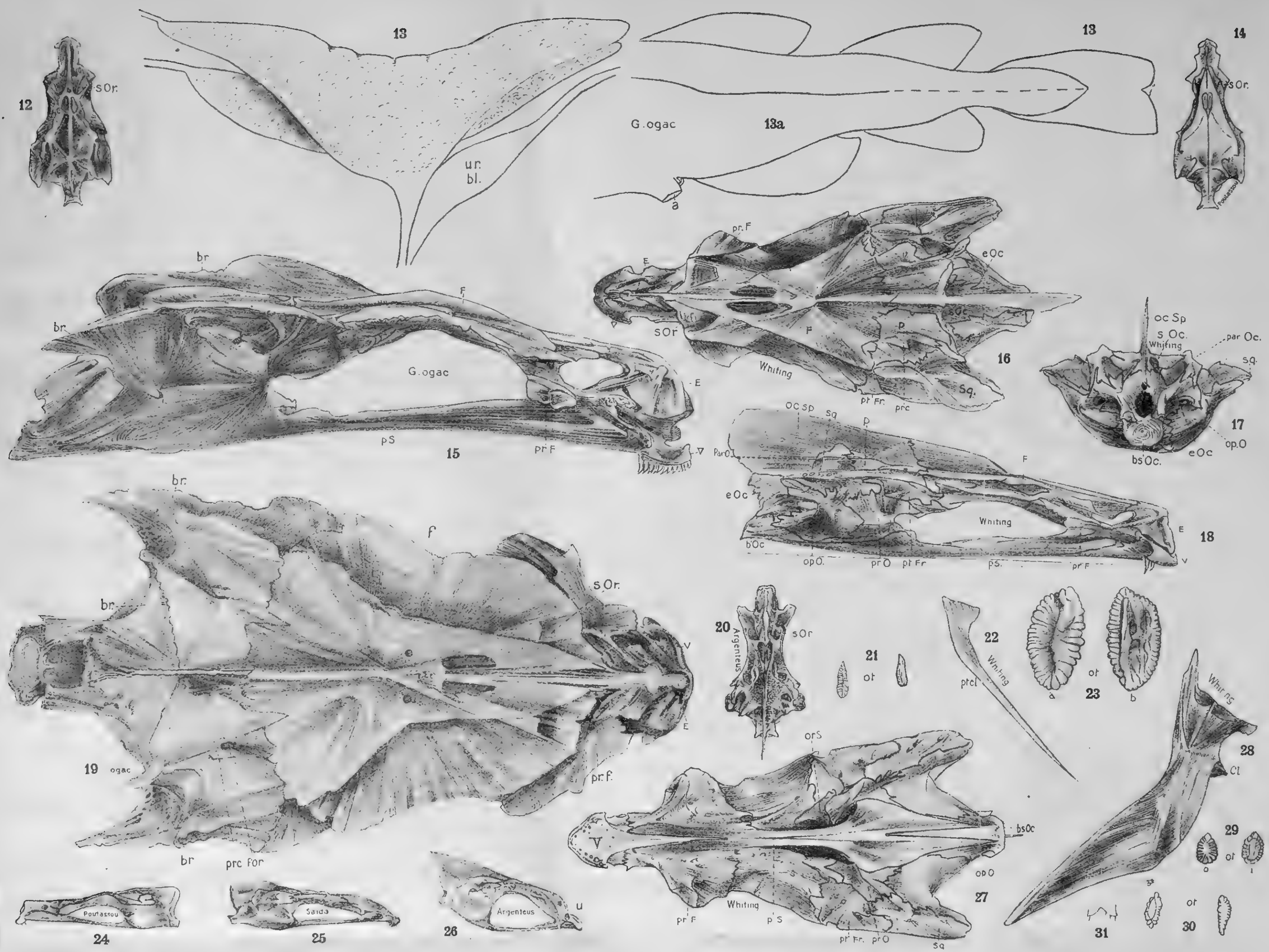
4

Gadus Sp.

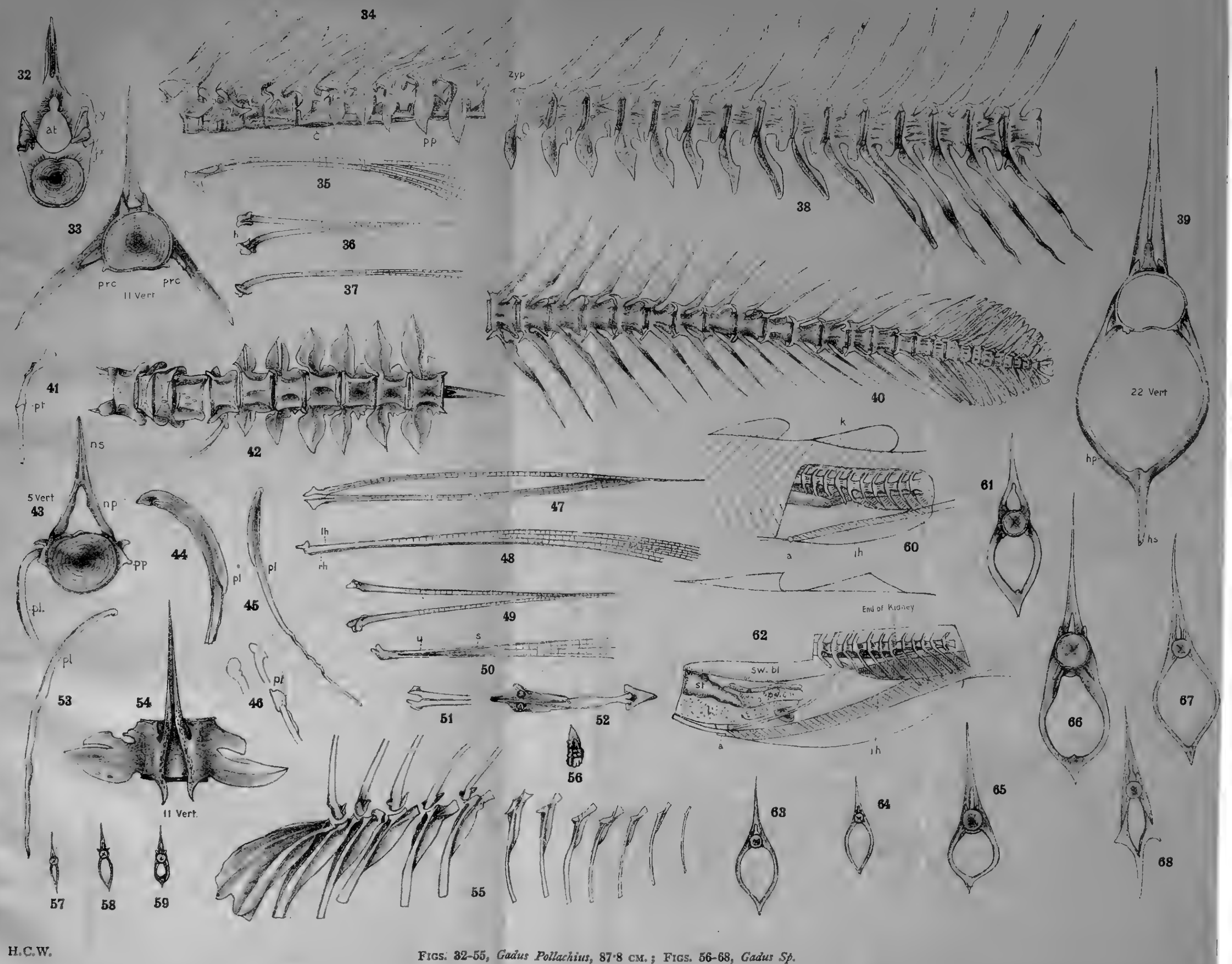
FIG. 1, A. H. WALKER.
FIGS. 2, 3, 4, H.C.W.

A. H. Walker.

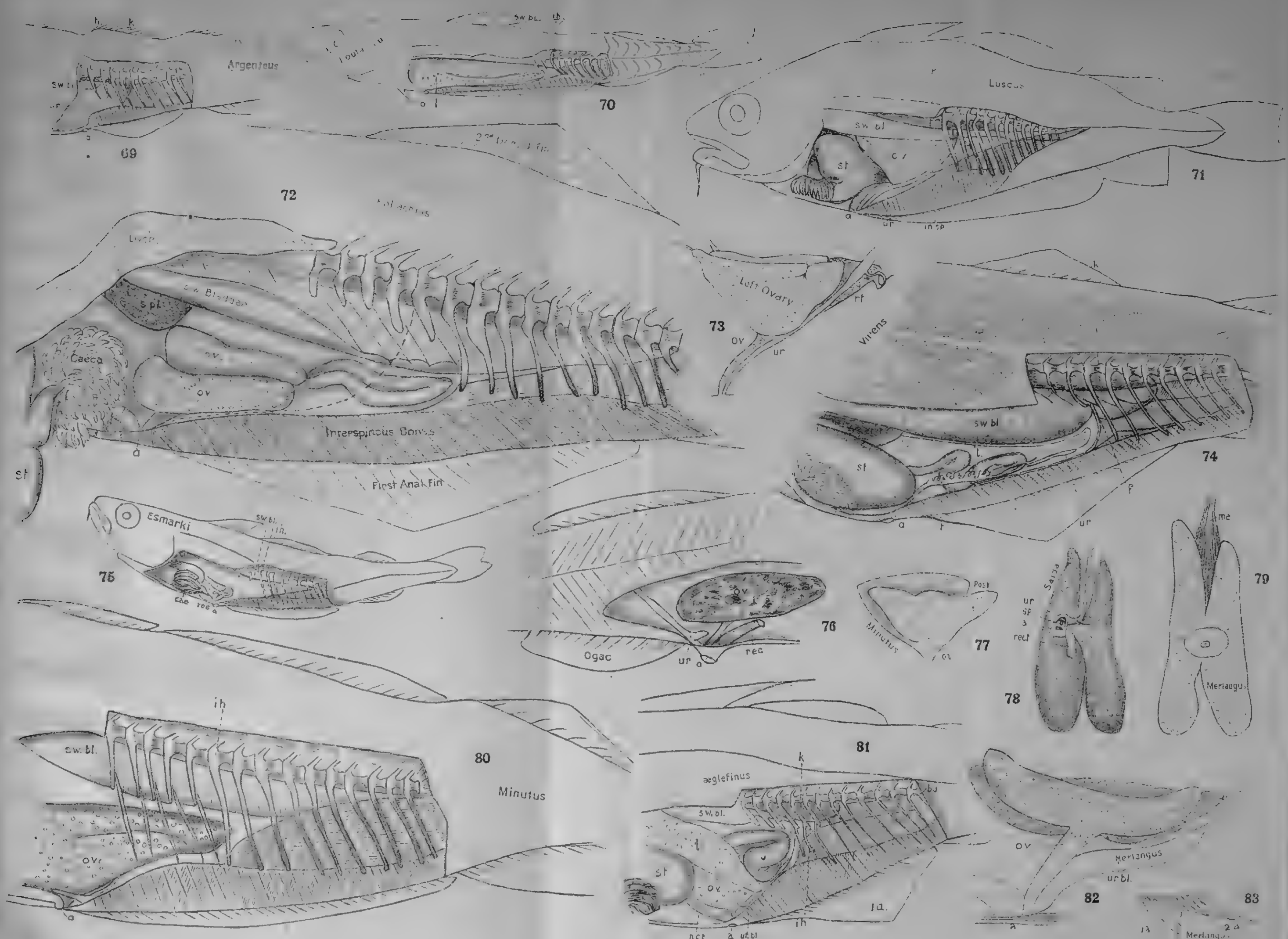
Gadus æglefinus.



A. H. Walker.   Figs. 16, 17, 18, 22, 27, 28, *Gadus Merlangus*; Figs. 12, 15, 19, 23, *G. ogac*;
H.C.W., Figs. 13, 13a, 14, 21, 24, 29, 30, 31;   Figs. 13, 25, 30, *G. saida*; Figs. 14, 21, 24, 31, *G. Poutassou*; Figs. 20, 26, 29, *G. argenteus*.
Fig. 23, after Vanhöffen;



FIGS. 32-55, *Gadus Pollachius*, 87·8 CM.; FIGS. 56-68, *Gadus Sp.*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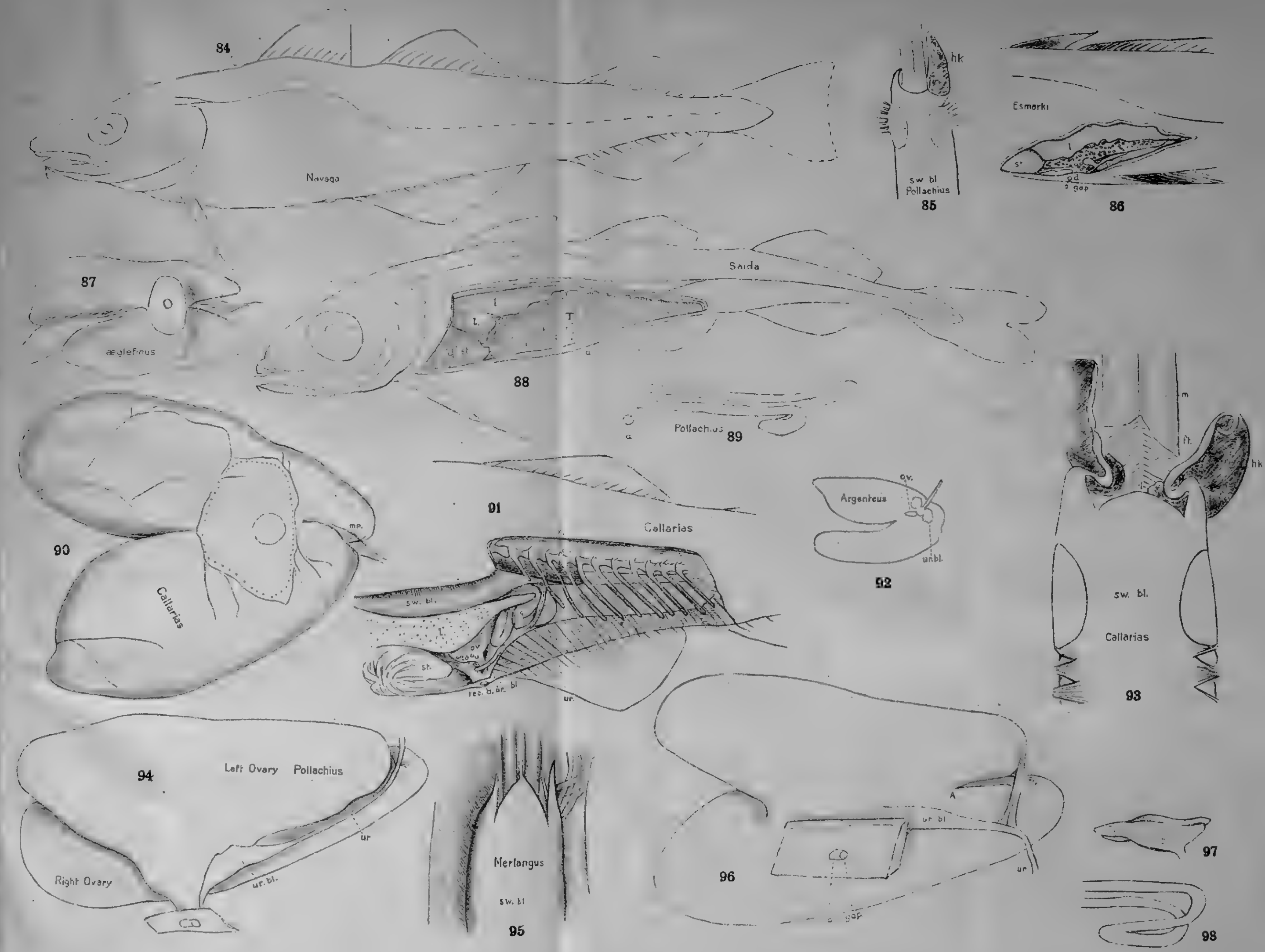
Merlangus

H.C.W.

Gadus Sp.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H.C.W.

Gadus Sp.

INDEX.